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OBSERVATIONS ON ACHORION GYPSEUM

C. W. EMMONS

(WITH PLATES 9 AND 10 AND 1 TEXT FIGURE)

Achorion gypseum Bodin is a pathogenic fungus which reproduces in culture by means of small single-celled conidia and large pluriseptate macroconidia, commonly called aleuries and fuseaux respectively by medical mycologists. Three cultures of this fungus were received from the laboratory of Dr. Sabouraud. One of these three strains, designated in our collection of cultures of human pathogens as No. 7, has been used in an attempt to learn whether cultures which grow from the small conidia differ from those which grow from the macroconidia or fuseaux. Ordinarily, in the transfer of cultures a mixture of these two types is used. *A. gypseum* is favorable for this study because on suitable media it produces both types of spores simultaneously and in large numbers. It is of further interest because it has been reported that it forms asci when grown on suitable substrates of animal origin such as leather and feathers.[1]

The fungus was named by Bodin,[2] who in 1907 isolated it from a typical case of favus. The patient was a woman thirty years of age who had on the right cheek an erythematous-

[1] Nannizzi, A. Ricerche sull'origine saprofitica dei funghi delle tigne. Il *Gymnoascus gypseum* sp. n. forma ascofera del *Sabouraudites* (*Achorion*) *gypseum* (Bodin) Ota et Langeron. (Nota preventiva.) Atti Accad. Fisiocritici Siena. X. **2**: 89–97. 1927. (Abstract in Rev. Appl. Myc. **7**: 169. 1928.)

[2] Bodin, E. Sur un nouveau champignon du favus (*Achorion gypseum*). Ann. Dermat. & Syph. **8**: 585–602. 1907.

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squamous lesion with four typical favus godets. Sabouraud [3] believes that this is the same fungus which he saw in 1894 and described briefly in his book "Trichophytes humaines" as the cause of a benign kerion. The fungus is of animal origin and has been isolated from the horse.[4] It resembles species of *Microsporum* of animal origin. Sabouraud finds that the fungus is capable of infecting the glabrous skin, the beard, or the scalp. Examination of the squames shows an abundant mycelium, and uninfected hairs are more numerous than infected ones. Of those infected, some hairs are invaded while others are surrounded by a sheath but are not invaded.

There is a close resemblance between *Achorion gypseum* and *Microsporum fulvum* and the two appear to be closely related. Ota and Langeron [5] place both of them in the genus *Sabouraudites*. Both produce some conidia and many macroconidia, and in old cultures the latter occur in great abundance. In *A. gypseum* the two types of spores are borne on different parts of the mycelium (PLATE 9, FIGS. 1*a*, 2), or they arise in close proximity (PLATE 9, FIG. 1*b*).

It seemed possible that the downy or "pleomorphic" type of culture which develops in old cultures might arise prevailingly from only one of the spore types which are present in this fungus. In a paper in which he puts forward a reclassification of the dermatophytes and records valuable cytological data for many forms including *A. gypseum*, Grigorakis [6] presents this hypothesis. He considers the term pleomorphism inappropriate and believes that the dermatophytes exhibit neither polymorphism nor pleomorphism but a monomorphism in which there is a progressive degeneration of both mycelial and fruiting structures. He believes the conidia are different in nature from the fuseaux and represent the degraded forms of the latter developed during this progressive degeneration. Observations made on mono-

[3] Sabouraud, R. Les Teignes, 571–591, 709–713. 1910.

[4] Urbain, Barotte & Capdebielle. Sur un cas de teigne équine due à l'*Achorion gypseum*. Bull. Mém. Soc. Centr. Méd. Vétér. **102**: 50. 1926. (Abstract in Rev. Appl. Myc. **5**: 555. 1926.)

[5] Ota, M. & Langeron, M. Nouvelle classification des dermatophytes. Ann. Parasitol. **1**: 305–336. 1923.

[6] Grigorakis, L. Dermatophytes et dermatomycoses. Ann. Dermat. & Syph. **10**: 18–68. 1929.

spore cultures would have given evidence bearing directly on the genetic nature of the different types of spores he studied, but he does not record such data.

The term pleomorphism was originally used in mycology to describe the supposed variability of fungi. Distinct species of fungi which often follow each other in impure cultures were at first thought to be different forms of a single species. Pure culture methods showed that *Mucor* and *Aspergillus*, for example, are not forms of the same organism. The words pleomorphism and, more commonly, polymorphism are still occasionally used by some mycologists to describe either the presence of two or more spore forms in a life cycle or the variability of a species.

Medical mycologists, on the other hand, have given to the term pleomorphism a special meaning. Sabouraud, when he first studied the overgrowth of white downy mycelium on his cultures, believed that he was observing a case of commensalism. He (l.c., p. 84) credits Bodin with being the first to show that this was not a correct interpretation. Bodin [7] believed that it was a case of " polymorphisme " such as had been demonstrated for many of the saprophytic fungi. Later he and Sabouraud together studied this phenomenon and distinguished between the words polymorphism and pleomorphism. Fox and Blaxall [8] seem to have been first to apply the term pleomorphism to this phenomenon although they apparently did not differentiate between pleomorphism and polymorphism. Sabouraud defines pleomorphism of the dermatophytes as a stable variation involving degeneration and loss of complexity and giving rise to a new form which can not revert to the original type. This view, from which that of Grigorakis differs fundamentally, is accepted by nearly all dermatologists. This conception is clearly stated by Brumpt,[9] who says: " Le polymorphisme est donc un simple *phénomène d'adaptation* qui ne doit pas être confondu avec le pléomorphisme. . . . Pour Sabouraud . . . *le pléomorphisme des*

[7] Bodin, E. Les teignes tondantes du cheval et leurs inoculations humaines. Thèse de Paris. 1895.

[8] Fox, T. C. & Blaxall, F. R. An inquiry into the plurality of fungi causing ringworm in human beings as met with in London. Brit. Jour. Dermat. **8**: 340. 1896.

[9] Brumpt, E. Précis de Parasitologie, 1147. 1927.

Champignons des teignes constitue une véritable variation stable, donnant naissance à des formes nouvelles cultivables et inoculables, incapables de revenir au type primitif même après passage sur l'animal et quand des conditions biologiques différentes lui sont offertes." The nature of this change is important to an understanding of the dermatophytes and their relations to their hosts. Sabouraud [10] in a recent article has called this change a fixed mutation. Whether or not it is comparable to the so-called mutations or saltations so frequently described in other fungi by mycologists is a question. A study of monospore cultures clearly shows that the two types of spores simultaneously produced by *A. gypseum* are of equal rank, and that the "pleomorphic" change is not due to the development of cultures from only one of these spore types.

It is obvious that monospore culture methods are important in these studies of variation in human pathogens as well as in the determination of heterothallism where they have yielded such brilliant results. Many methods and many mechanical devices have been employed in the isolation of single spores from which cultures can be secured. For very minute spores special spore pickers are useful, especially in the hands of an expert. However in most cases no apparatus is required other than a dissecting microscope and a very fine needle honed down to a cutting chisel-like edge. The method described below is in common use by many mycologists. A suspension of the spores of the fungus is made in sterile distilled water or saline. This suspension is poured or sprinkled over the surface of a plate of four per cent cornmeal agar or other hard clear agar. The liquid is then evenly spread over the surface of the plate by tilting it or by streaking with a loop, and it is soon absorbed by the hard agar. The suspension must be sufficiently heavy so that the spores are well separated without being too close together to be picked out later, or so far apart as to be difficult to find. The Petri dish is now set aside until the spores germinate. In the case of *A. gypseum* this will be within 10 hours (TEXT

[10] Sabouraud, R. Généralités concernant les dermatophytes. Le problème du pléomorphisme des cultures des dermatophytes. V^e^ Mémoire. Ann. Dermat. & Syph. **10**: 481–486. 1929.

FIG. 4). Germination begins within 3 or 4 hours, but if left for 8 or 10 hours practically all the viable spores have begun to germinate and it is then possible to choose spores which are certainly isolated. The plate is uncovered and placed on the stage of a dissecting microscope with an objective of moderate magnification. The microscope stage and table top should be wetted down with lysol, and subsequent operations must take place in a room with windows closed and free from floating dust

FIG. 1. Germinating macroconidia after ten hours.

and spores. A spore well isolated is chosen and is then cut out with a very fine steel needle while under observation through the microscope. It is then picked up and transferred to a tube or plate. Either the entire germinated spore or a free hyphal tip from it can be transferred in this manner. It is convenient to dip the needle between transfers into a vial of alcohol and flame quickly in order to avoid burning away the fine needle point. After a little practice this method can be readily employed, and under ideal conditions single spore cultures can be made easily,

quickly, and with confidence that not more than one spore was used as the inoculum.

Single spore cultures were made using both the small conidia and the macroconidia. The two types of cultures gave nearly identical pictures (PLATE 10). The only observable difference was in the gross appearance of the colonies. Those from the macroconidia were in nearly all cases slightly larger than the others and appeared to be 24–48 hours in advance of the other type. This is easily explained when one examines the germinating spores. The macroconidia germinate before the conidia and produce much larger germ tubes. The mycelial network arising from such a spore receives a more vigorous start (PLATE 9, FIG. 4). This is perhaps due to the greater amount of food in the spore. Plate 10, figure 7, shows a photograph of a plate culture on Sabouraud's maltose agar medium, the culture originating from a single conidium of *A. gypseum*. Figure 10 is of a culture of the same age and on the same medium which developed from a single macroconidium. Microscopically the cultures are identical. There is the same proportionate occurrence of the spore forms in both, and subcultures from the two cultures give identical pictures both macroscopically and microscopically. Figures 8 and 11 are of other plate cultures, and figures 9 and 12 are of tube cultures corresponding in a similar manner. Both types of cultures become covered by the " pleomorphic " overgrowth of mycelium at about the same time. This pleomorphic mycelium produces very many conidia and a few small two- to four-celled macroconidia. Monospore cultures from these two types of spores are alike in every way. The cultures are pleomorphic, differing from the parent culture by lack of pigmentation, more abundant aerial mycelium, and relatively larger numbers of the small conidia. Some change has occurred in the fungus, but it is a change which has affected both types of spores. The spores which are simultaneously produced on the mycelium appear still to be identical in their nature.

Many other cultures from single conidia and macroconidia were studied in other series, and the results were always the same. I find also that in an extended series of cultures derived from single conidia and macroconidia of a fungus of the *Trichophyton*

gypseum group the two kinds of spores give identical cultures. There is no evidence that the two types of spores which are formed simultaneously are genetically different. The conidia formed in pleomorphic cultures do, however, differ from those formed in the original type of culture. Just how and where this change takes place is not yet clear.

For a study of the nuclear condition colonies of the fungus growing on agar were fixed, sectioned, and stained. Young colonies should be chosen, and there is some advantage in using such a culture medium as cornmeal agar [11] which often stimulates spore production but does not favor the development of an extensive cottony mycelium. Several different fixatives were tried. Best fixation was secured with Flemming's weaker fluid allowed to act for one hour.

The cells of *A. gypseum* are comparatively long and are multinucleate as is shown in plate 9, figure 6*a*. This fact has also been noted and figured by Grigorakis. The presence of as many as 18 nuclei in one cell has been noted although there are not usually so many. These nuclei are variable in their arrangement and position. They may be paired in the cell as though two newly formed daughter nuclei had not yet separated, or they may be scattered. In some cases the nuclei are near one end while in others they are distributed throughout the length of the cell. The young macroconidia are also multinucleate (PLATE 9, FIGS. 6*b*, *c*). At germination the cells of these spores contain several nuclei (PLATE 9, FIG. 5). As many as ten may be present. The conidia are usually uninucleate but may contain two nuclei. Each nucleus contains one large nucleole. I was unable to observe a chromatic reticulum, and the nuclear membrane is very difficult to make out in many nuclei.

Cultivation of this and other pathogenic fungi on various organic substrates such as silk, wool, feathers, litter, and wood has been reported.[12] I have cultivated *A. gypseum* on a variety

[11] To 3 liters of distilled water add 125 g. cornmeal (water ground); heat in water bath 1 hr. at 60° C.; filter through filter paper; make up to 3000 cc.; add 37.5 g. agar (1¼%); steam for 1¼ hrs.; filter through absorbent cotton; flask and sterilize in autoclave at 15 lbs. pressure 30 min.

[12] Kadisch, E. T. Über das Fortkommen der pathogenen Hautpilze ausserhalb des Körpers. Dermat. Wochenschr. **89**: 1423–1433. 1929.

of media with the hope of securing other fruiting forms. It grows well on sterilized human skin, nail parings, horn, wool, feathers, and on agar to which the only nutrient added was finely divided horn, and it liquefies gelatine; but on all of these it has so far produced only its usual spore forms. It does however occasionally produce spirals when grown on nail parings. Langeron and Milochevitch [13] report the presence of spirals in *A. gypseum* when it is grown on various grains. Nail parings sterilized in tubes in the bottoms of which have been placed moistened wads of cotton are, after inoculation with *A. gypseum*, quickly overgrown and the substance of the nail is destroyed. Horn is equally suitable as a culture medium.

Summary: Conidia and macroconidia (fuseaux) of *Achorion gypseum* are not genetically different. The hyphal cells and the macroconidia are multinucleate; the small conidia have one or sometimes two nuclei. Spirals such as those which are considered characteristic for *Trichophyton asteroides* are sometimes produced when the fungus is grown on nail parings. It grows well on nail parings and on pieces of horn and destroys the substrate.

Dr. R. A. Harper, Dr. J. G. Hopkins, and Dr. B. O. Dodge have offered helpful criticisms during the preparation of this paper.

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EXPLANATIONS OF PLATES

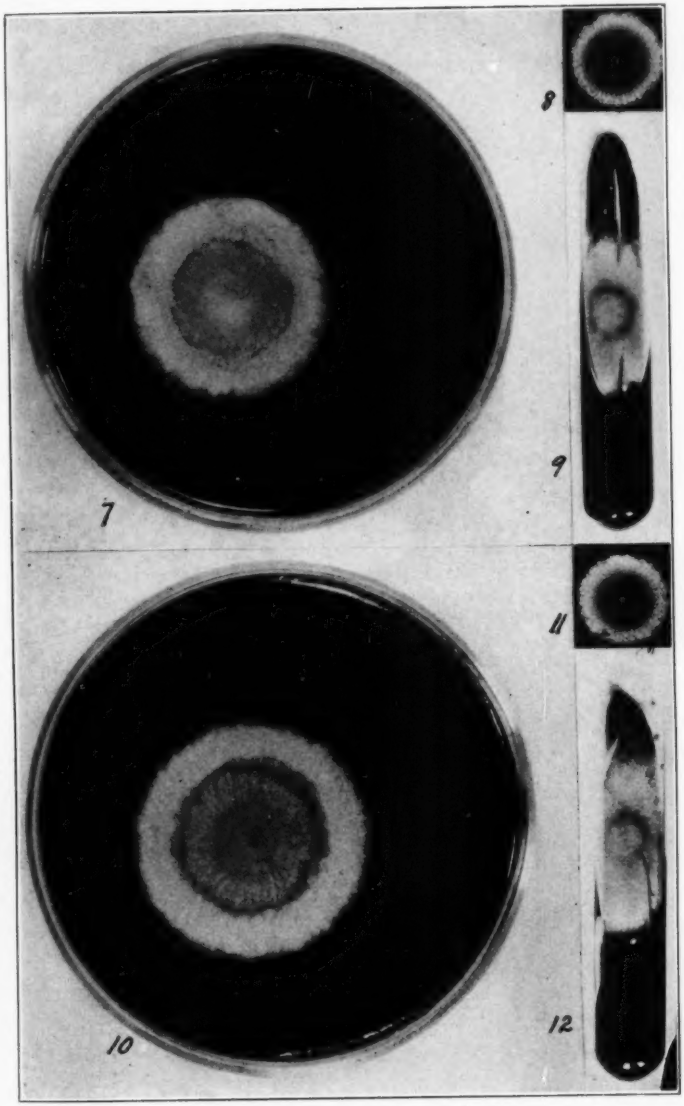
PLATE 9

Fig. 1. Mycelial branches bearing spores: *a*, a branch bearing conidia only; *b*, conidia and macroconidia produced on adjacent branches of the mycelium. × 470.

Fig. 2. A cluster of macroconidia showing spores of different ages. × 470.

Fig. 3. Typical groups of macroconidia. Cornmeal agar culture. Some of the spores have germinated by sending out a germ tube from the free end. × 100.

[13] Langeron, M. & Milochevitch, S. Morphologie des dermatophytes sur milieux naturels et milieux a base de polysaccharides. Ann. Parasitologie **8**: 422–436. 1930.



ACHORION GYPSEUM

Fig. 4. Germinating conidia and macroconidia after five hours on agar at room temperature. × 470.

Fig. 5. Germinating macroconidium stained. × 1300.

Fig. 6. A vegetative hypha and two young macroconidia stained to show nuclei. × 1300.

PLATE 10

Fig. 7. Plate culture on Sabouraud's maltose agar medium of a monospore culture of *Achorion gypseum* derived from a single conidium.

Fig. 8. Same as Fig. 7.

Fig. 9. Tube culture from a single conidium.

Fig. 10. Plate culture on Sabouraud's maltose agar medium of a monospore culture derived from a single macroconidium.

Fig. 11. Same as Fig. 10.

Fig. 12. Tube culture from a single macroconidium.

NOTE. While this paper was in press a strain of *Achorion gypseum* has been isolated in this laboratory by Miss R. W. Benham. It was recovered from a white boy five years of age with a kerion of the scalp. There were no lesions suggesting favus. This is apparently the first instance of the observation of *A. gypseum* or the probably identical species, *Microsporum fulvum*, in this country. Bloch, in his Handbuch der Haut- und Geschlechtskrankheiten, Vol. 11, page 81, states that it was reported from New York by Mewborn in 1903. Mewborn in volume 21, pages 11–18, of the Journal of Cutaneous Diseases for 1903 does describe a fungus which he isolated from ringworm and favus-like lesions on the same patient. An examination of his description and photographs of cultures however make it appear that he did not have the fungus which Bodin isolated and described four years later.

THE RUSTS OF SOUTH AMERICA BASED ON THE HOLWAY COLLECTIONS—III [1]

H. S. Jackson

(With Plate 11 and 5 Text Figures)

The present contribution is the third of a series [2] bearing the same title. This number contains a continuation of the records of the rusts on Berberidaceae and on other host families in the order given in Engler and Prantl through the Rosaceae.

In order to facilitate indexing each species is given a number and the numbering is consecutive for the three papers. Including those recorded in this paper, a total of 99 species and 220 collections are now accounted for. In a few cases reference is made to species not included in the Holway collections. Where such references are of an important character a duplicate number has been given with the suffix *a*, *b*, etc., in order to keep the numbering of the species in the Holway collections consecutive.

Species on Berberidaceae

(*continued*)

83. **Puccinia Berberidis-Darwinii** Jackson & Holway, nom. nov.

Caeoma Berberidis Diet. & Neger; Engl. Bot. Jahrb. **27**: 13. 1899. Not *C. Berberidis* (Lév.) Har. 1891, nor *P. Berberidis* Mont. 1856.

Berberis Darwinii Hook. f. Lago Llanquihue, Chile, Dec. 2, 1919, I, III. *196;* Puella, Lago Todas los Santos, Chile, Nov. 30, 1919, I. *193.*

This interesting species was first described as *Caeoma Berberidis* Diet. & Neger. It has apparently not often been collected, as the only previous record seems to have been that for the type collection which was made on the same host in Chile, by Neger.

[1] Joint contribution from the Department of Botany, Purdue University Agricultural Experiment Station, and the Department of Botany, University of Toronto.

[2] See Mycologia **18**: 139–162. 1926; **19**: 51–65. 1927.

Our specimens do not show any amount of hypertrophy in association with aecial infection but the sori occur singly or in small groups on the underside of the leaves.

Pycnia have not been described for this species but are abundant in collection *193*. They are either epiphyllous or hypophyllous but more commonly epiphyllous, obovate or globoid, deep seated, 100–125 by 110–150 μ. Telia occur in collection *196*. These are hypophyllous, scattered and subepidermal. Aeciospores (?) occur in many of these sori. These are in short chains as in the aecia. Such sori are apparently unaccompanied by pycnia. The teliospores are clavate, rounded above and narrowed below, 16–20 by 55–80 μ. The upper cell varies in length from ½ to ¾ that of the lower cell. The wall is 1½–2½ μ in thickness, with the apex gradually thickened, 3–3½ μ. The pedicel is colorless, persistent, equaling the spore in length or longer. The pore in the upper cell is apical.

This very interesting species raises some important questions as to its systematic position. The aecia are not aecidium-like but resemble those of *Gymnoconia* or *Phragmidium*. The pycnia are, however, sub-epidermal. The occurrence of spores identical with the aeciospores in the telial sori suggests that this species possesses repeating aecia as in *Puccinia Senecionis*, *Uromyces Hedysari-obscuri*, etc., but with quite different gross morphology.

These characters might justify the erection of a new genus to accommodate this species but we feel that until a detailed cultural study is available, and until a more detailed morphological study has been made than is possible with the relatively meager material at our disposal, it is preferable to include it in *Puccinia*.

Edythea Jackson, gen. nov.

Uredinia and telia superficial, formed at the apex of erect hyphae which emerge singly or in groups of two or three through the stomata of the host. Urediniospores and teliospores stipitate, originating from cells formed as the result of a close, short, irregular branching at or near the apex of the emerged hyphae. Teliospores two-celled with a single germ pore in each cell.

Type species. *Uropyxis quitensis* Lagerh. 1918.

This genus is erected to accommodate three species of rusts occurring on *Berberis* in South America. A careful study has revealed that both urediniospores and teliospores are borne in a very characteristic and presumably unusual manner. There is no sorus in the usual sense of the term. Mycelial threads emerge singly or in groups of two or three, rarely perhaps more, from the stomata. The stomata are not ruptured. There is no appreciable fungus tissue in the substomatal cavity. It appears that some of the mycelium threads which reach this cavity merely

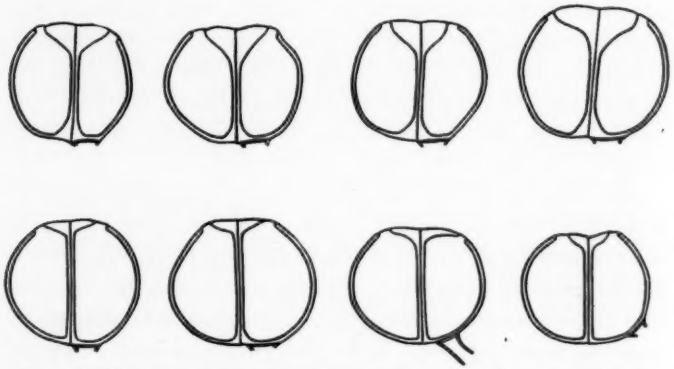


FIG. 1. *Edythea quitensis*. Spores from Holway collections *980* and *918*.

turn outward through the stomatal opening and, having emerged, form a close system of short branches from the ultimate cells of which the urediniospores or teliospores arise on short colorless pedicels (FIGURES 4 AND 5). The gross appearance is that of an olive-green or cinnamon-brown hyphomycete. In all three species the teliospores germinate as soon as formed by the development of a four-celled basidium. The urediniospores in the three species are much alike. The teliospores are, however, quite different. The following key will serve to separate the species.

Teliospores as in *Sphenospora*, with vertical septum . . 84*a*. *E. Berberidis*.
Teliospores as in *Puccinia*, septum variable.
Teliospores nearly globoid . . . . . 84. *E. quitensis*.
Teliospores ellipsoid . . . . . 85. *E. tenella*.

84. **Edythea quitensis** (Lagerh.) Jackson & Holway, comb. nov.

Uropyxis quitensis Lagerh.; Arth. Bot. Gaz. **65**: 464. 1918.
Sphenospora quitensis Lagerh. in herb. Arth.

Berberis phyllacantha Rusby. Sorata, Bolivia, Apr. 27, 1920. *579.*

Berberis sp. Quito, Ecuador, August 18, 1920. *918;* Cuenca, Ecuador, September 12, 1920. *980.*

This species is based on a specimen in the Arthur herbarium collected by G. Lagerheim at Quito, Ecuador, in April 1891. This specimen is labeled *Sphenospora quitensis* Lagerh. n. sp. It was first described by Arthur in 1918 as *Uropyxis quitensis* Lagerh. The three collections made by the Holways agree well with the type. In this species the spores are nearly spherical, about as long as broad, with the pedicel variously attached with reference to the septum (FIG. 1).

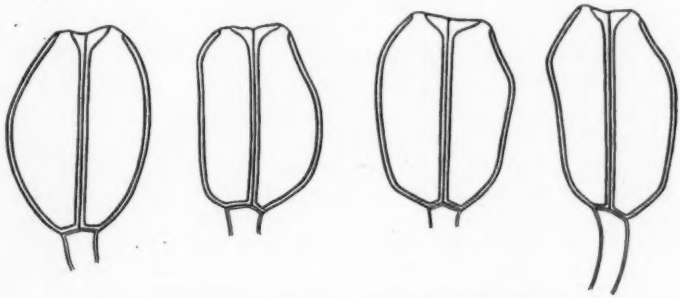


FIG. 2. *Edythea Berberidis.* Spores from type collection.

84*a*. **Edythea Berberidis** (Lagerh.) Jackson, comb. nov.

Sphenospora Berberidis Lagerh.; Arth. Bot. Gaz. **65**: 464. 1918.

Diorchidium Berberidis Lagerh. in herb. Arth.

This species is known from a single collection made on *Berberis glaucescens* St. Hil. at Tahatanga, Ecuador, in September 1891 by G. Lagerheim. The type specimen was labeled *Diorchidium Berberidis* Lagerh. n. sp. In gross features this species has the

same habit as *Edythea quitensis*. The teliospores are, however, quite different in that the spores are much narrower in proportion to their length and the septum is quite uniformly vertical, the pedicel being attached at or near the septum (FIG. 2). This species was not collected by the Holways but is inserted here as its relationship is clearly with this genus.

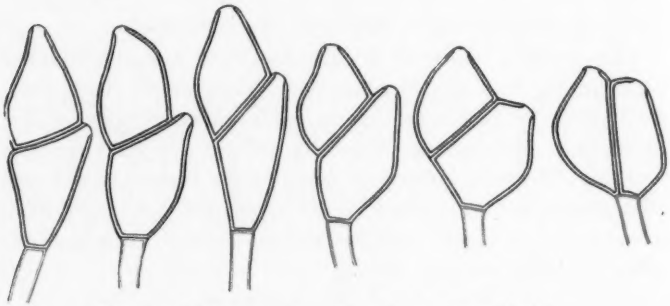


FIG. 3. *Edythea tenella*. Spores from type collection.

85. **Edythea tenella** Jackson & Holway, sp. nov. ? (TEXT FIGURES 3, 4 AND 5.)

II. Uredinia hypophyllous, superficial and effused, occurring in scattered greyish patches ½–2 mm. across; urediniospores borne on basal cells originating from the close branching of threads which emerge singly or in groups of 2 or 3 from the stomata, globoid, 23–25 μ in diam.; wall thin, 1–1½ μ, evenly, prominently and rather closely echinulate; pores obscure.

III. Telia like the uredinia, cinnamon-brown; teliospores variable, ellipsoid or fusiform, 16–20 by 30–50 μ, rounded or slightly narrowed above and below, constricted at the septum, germinating at once; wall light golden brown, 1 μ in thickness, slightly thickened about the germ pores which are located in the apex in the upper and near the septum in the lower cell; pedicel short, colorless.

Berberis divaricata Rusby. Sorata, Bolivia, April 22, 1920. *564* (type).

This species differs from the other two in the character of the teliospores. The majority of these are ellipsoid and not unlike many species of lepto-*Puccinia*. Many of them, however, are

quite variable in shape due to the variable position of the septum. In some spores the septum is oblique and the walls round out giving a characteristic appearance. In others the septum becomes nearly vertical, approaching the condition in *E. Berberidis* (FIG. 3). This type collection has an *Aecidium* on the fruits but we hesitate to suggest that they belong with the uredinia and telia.

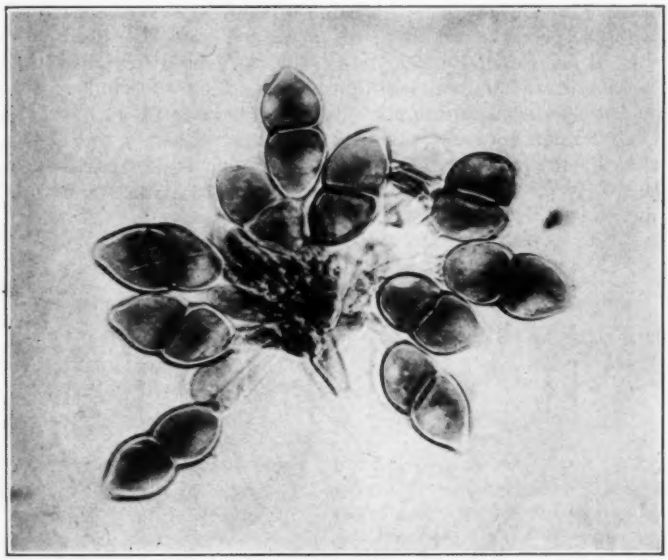


FIG. 4. *Edythea tenella.* Photograph from type collection showing cluster of spores originating from a single hypha which has emerged through a stomate.

86. PUCCINIA MONTANENSIS Ellis, Jour. Myc. **7**: 274. 1893.
Dicaeoma montanensis Kuntze, Rev. Gen. **33**: 469. 1898.

Berberis sp. Termas de Chillán, Chile, Dec. 28, 1919, I. *254.*

This *Aecidium* on *Berberis* was assigned, as indicated above, by Arthur in his contribution to the grass rusts of South America

(Proc. Am. Phil. Soc. **44**: 167. 1925). It is included here for the sake of completeness. Uredinia and telia occur in South America on several species of *Bromus* and *Elymus*.

SPECIES ON LAURACEAE

87. **Aecidium Nectandrae** Jackson & Holway, sp. nov.

O. Pycnia epiphyllous, numerous, scattered on discolored spots, globoid, very large, 170–210 μ, deep seated, arising from below the palisade layer, finally rupturing the epidermis with ostiole as broad as the diameter of the pycnium.

I. Aecia hypophyllous, numerous, scattered on discolored spots 1–3 cm. across; peridium short, cylindric, firm, erose at margin; peridial cells rhombic in cross section, 18–20 μ long by 15–20 μ high, outer wall 1.5–2.5 μ, smooth, inner wall 2–3 μ, roughly tuberculate; aeciospores ellipsoid or short cylindric, 16–20 by 23–28 μ; wall finely and prominently verrucose, the apex thickened, 3.5–5.5 μ.

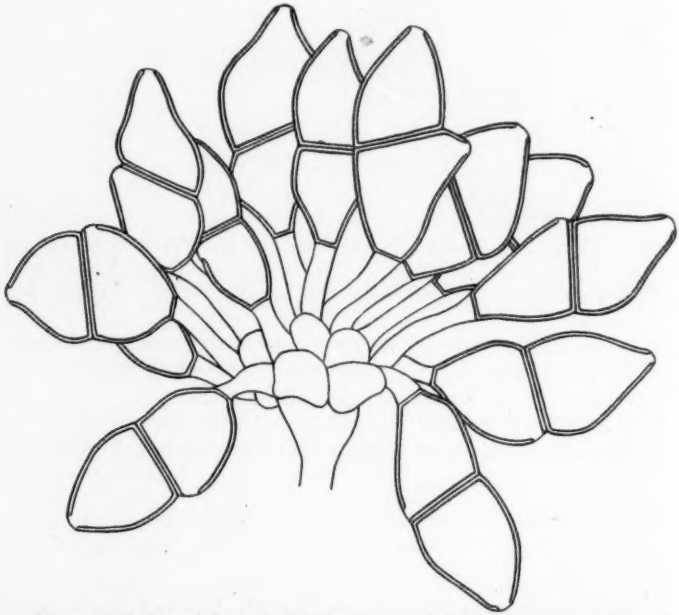


FIG. 5. *Edythea tenella*. Drawing from type collection showing cluster of spores originating from a single hypha which has emerged through a stoma.

Nectandra oppositifolia Ness. Bello Horizonte, Minas Geraes. Brazil, November 26, 1921. *1339.*

This appears to be a very distinct species occurring on large spots which sometimes coalesce covering considerable areas. The pycnia are very large and when mature have a spreading ostiolum appearing in cross-section to be short cylindric with a rounded base deeply seated in the tissues of the host.

SPECIES ON CAPPARIDACEAE

88. **Puccinia Cleomis** Jackson & Holway, sp. nov.

O. Pycnia not seen, probably not present.

III. Telia hypophyllous, small, 0.2–0.5 mm. across, closely gregarious in small group 2–3 mm. across on discolored spots, early naked, pulvinate, firm, ruptured epidermis not conspicuous; teliospores broadly ellipsoid or clavate, 19–24 by 35–44 μ, apex rounded, base rounded or somewhat tapering; wall thin, 1.5–2.5 μ, broadly thickened at apex, 3–4 μ, smooth; pedicel colorless, firm, equaling the spore or shorter, occasionally longer.

Cleome gigantea L. San Felipe, Sur Yungas, Bolivia, May 21, 1920. *634.*

SPECIES ON SAXIFRAGACEAE

89. **Uromyces ribicola** Jackson & Holway, sp. nov.

II. Uredinia hypophyllous, numerous, scattered, small, round, 0.2–0.5 mm. in diameter, golden-brown; urediniospores globoid or broadly ellipsoid; wall colorless, 2–3 μ in thickness below, irregularly and greatly thickened, 10–13 μ above, evenly and moderately echinulate; pores obscure, several.

III. Telia like the uredinia, whitish, ruptured epidermis not conspicuous; teliospores cylindrical or occasionally bent to one side near apex, 16–19 by 75–115 μ; wall colorless, very thin, 1 μ or less, not thickened at apex, no germ pore evident, germinating at once.

Ribes albiflorum R. & P. Sorata, Bolivia, Apr. 22, 1920. *568.*

This species is assigned to *Uromyces* with considerable doubt. The teliospores are thin-walled and uninterrupted in development. It appears that in the development of teliospores there is no cessation of growth till the basidium is fully formed and there

is no point at which one may say that the spore ends and the basidium begins.

This characteristic is similar to that of the genus *Chrysocyclis* Sydow (*Holwayella* Jackson). In *Chrysocyclis*, however, the spores are two-celled and the fully developed spore and basidium has a characteristic appearance which the writer has described as "mitten-like." *Chrysocyclis*, however, according to the writer's present interpretation, represents a lepto-*Puccinia* in which the sori are waxy and the basidium develops from the spore with no interruption. It is, therefore, questionable whether this character is sufficiently important to justify generic separation. To the writer it represents a natural simplification in morphology which has arisen in certain tropical rusts which germinate at once. The relatively thick firm walled teliospores with a definite pore, characteristic of nearly all rusts of temperate regions, may be interpreted as a morphological adaptation necessary to a resting condition. The absence of this characteristic does not necessarily justify generic separation.

SPECIES ON ROSACEAE

90. PHRAGMIDIUM DISCIFLORUM (Tode) J. F. James, Contr. U. S. Nat. Herb. **3**: 276. 1895.

Ascophora disciflora Tode, Fungi Meckl. **1**: 16, 1790.

Rosa sp. (cult.). San Felipe, Chile, Sept. 25, 1919. *73;* Panamaruda, Chile, Dec. 16, 1919. *238;* La Paz, Bolivia, March 20, 1920. *442.*

91. PUCCINIASTRUM AGRIMONIAE (Schw.) Tranz. Scripta Bot. Hort. Univ. Petrop. **4**: 301. 1895.

Caeoma (*Uredo*) *Agrimoniae* Schw. Trans. Am. Phil. Soc. II. **4**: 291, 1832.

Agrimonia hirsuta Bong. Campos do Jordão, São Paulo, Brazil, Apr. 25, 1922. *1770.*

92. TRANZSCHELIA PUNCTATA (Pers.) Arth. Résult. Sci. Congr. Bot. Vienne 340. 1906.

Aecidium punctatum Pers. Ann. Bot. Usteri **20**: 135. 1796.

Puccinia Pruni-spinosae Pers. Syn. Fung. 226. 1801.

Prunus Persica (L.) Stokes. Cochabamba, Bolivia, Feb. 26, 1920. *334;* Hacienda del Urco, Urubamba Valley, Cuzco, Peru, July 4, 1920. *762.*

ON THE GENUS RUBUS

In connection with the study of the Holway rust collections on the genus *Rubus*, the writer has encountered several interesting situations and it seems desirable at this time to present a preliminary synopsis covering all the rust species occurring on the genus *Rubus* in Central and South America. In connection with this study the writer has also had availab'e several collections made by Dr. F. L. Stevens in Ecuador and Peru. These together with other South American collections from various sources are also recorded, for the sake of completeness.

Among other things it has been discovered that the teliospores of *Spirechina Loeseneriana* and *S. Arthuri* occur in chains. This necessitates a transfer of these species to *Kuehneola*. Since *S. Loeseneriana* was designated the type of the genus *Spirechina* that generic name now becomes synonymous with *Kuehneola* and a new name is provided for the species with one-celled teliospores. We do this with the conviction that the re'ationship of the group of *Rubus* rusts characterized by one-celled teliospores is with *Kuehneola* and the Phragmidiatae and not with the Dicaeomatae. To leave them in *Uromyces* does not properly bring out this relationship.

In addition to the forms discussed here, *Kuehneola andicola* (Diet. & Neger) Diet. occurs in South America. We have not been able to assign properly *Uredo imperialis* Speg. because of the lack of authentic material.

93. **Kuehneola Loeseneriana** (P. Henn.) Jackson & Holway, comb. nov.

Uredo Loeseneriana P. Henn. Hedwigia **37**: 373. 1898.
Uromyces Usterii Speg. Rev. Mus. La Plata **15**: 7. 1908.
Uromyces Loeseneriarus Sydow, Monog. Ured. **2**: 202. 1910.
Spirechina Loeseneriana Arth. Jour. Myc. **13**: 30. 1907.

Rubus brasiliense Mart. Barbacena, Minas Geraes, Brazil, Dec. 12, 1921, II. *1384.*

Rubus erythroclados Mart. Campos do Jordão, São Paulo, Brazil, Apr. 22, 1922, II, III. *1752.*

Rubus floribundus H.B.K. Hacienda La Florida, Prov. Sur Yungas, Bolivia, May 28, 1920. *673;* San Felipe, Prov. Sur Yungas, Bolivia, May 19, 1920. *621.*

Rubus urticaefolius Poir. São Paulo, Brazil, Jan. 25, 1922. *1500;* Santa Anna, São Paulo, Brazil, Feb. 21, 1922, II. *1577.*

Rubus sp. Therezopolis, Rio de Janeiro, Brazil, Sept. 29, 1921, I, II, III. *1167;* Petropolis, Rio de Janeiro, Brazil, Oct. 30, 1921. *1262;* Bello Horizonte, Minas Geraes, Brazil, Nov. 26, 1921, II. *1341;* Friburgo, Rio de Janeiro, Brazil, Jan. 2, 1922, I. *1443;* Poços de Caldas, São Paulo, Brazil, Apr. 8, 1922, II, III. *1712;* Campos do Jordão, São Paulo, Brazil, Apr. 20, 1922, I, III. *1739;* Reserva Florestal, Itatiaya, Brazil, May 13, 1922, I, II, III. *1845.*

93*a*. **Kuehneola Arthuri** (Sydow) Jackson, comb. nov.

Uromyces Arthuri Sydow, Monog. Ured. **2**: 203. 1910.
Spirechina Arthuri Arthur, N. Am. Fl. **7**: 183. 1912.

This species, as shown by the character of the markings on the urediniospores, is closely related to *K. Loeseneriana*. A careful study of the teliospores shows that they may occur in short chains though this is not easily demonstrated, as the spores soon separate.

K. Arthuri has apparently so far been reported only from Guatemala.

MAINSIA Jackson, gen. nov.

The generic name *Mainsia* is proposed as a substitute for *Spirechina* Arth. (Jour. Myc. **13**: 30. 1907). This genus is needed to include those forms which show relationship to *Kuehneola*, the teliospores of which occur singly on short pedicels, not in chains. The name proposed is in honour of my former associate, Dr. E. B. Mains, whose contributions to uredinology are of far reaching importance.

The generic diagnosis is in general as given by Arthur for *Spirechina* (N. Am. Fl. **7**: 182. 1912) with some modification. In these forms carefully studied by the writer the pycnia are not strictly subcuticular. Neither are they subepidermal but rather intra-epidermal. When the sori, whether pycnia, uredinia, or telia, occur on the upper surface, and possibly also when hypophyllous, the epidermal cells in the vicinity of the sorus are considerably hypertrophied so that the epidermis is considerably thicker in the infected region than elsewhere. The pycnia, uredinia, and telia develop as cavities in this hypertrophied epidermis and when nearly mature are covered by the cuticle and the upper epidermal wall. The side walls of the epidermal cells seem to be digested during the formation of the sorus.

The genus may include species which are microcyclic, as for example *M. Rubi-urtici* and *M. quitensis*. Paraphyses are present in some species. Most of the species appear to be of the brachy-type of life history. The primary uredinia usually occur on the upper surface, while the secondary uredinia and telia are usually on the under surface of the leaves.

To this genus should also be assigned the Asiatic species **Mainsia chinensis** (Diet.) Jackson, comb. nov. (*Spirechina chinensis* Diet. 1928), and the European **Mainsia urediniformis** (J. Mull.) Jackson, comb. nov. (*Uromyces urediniformis* (J. Mull.) Diet. 1912).

KEY TO THE AMERICAN SPECIES OF MAINSIA

Uredinia present, brachy-forms.
- Urediniospore wall markings echinulate or verrucose.
  - Markings of urediniospore wall coarse and sparsely placed.
    - Base of urediniospore markings elongated longitudinally..... 93*b*. *M. peruviana*.
    - Base of urediniospore markings rounded or nearly so. 94. *M. Holwayii*.
  - Markings of urediniospore wall rather fine.
    - Markings noticeably more prominent at apex.
      - Markings forming a distinct crown at apex..... 94*a*. *M. Pittieriana*.

Markings not forming a crown at apex.
Teliospores 24–32 μ. 94*b*. *M. Rubi.*
Teliospores 28–48 μ long. 97. *M. tenella.*
Markings not noticeably more conspicuous at apex.
Teliospores thickened at apex; paraphyses present.
Urediniospores small, 20–26 μ long..... 95. *M. Lagerheimii.*
Urediniospores large, 25–35 μ long..... 96. *M. variabilis.*
Teliospores not thickened at apex; paraphyses absent.
Teliospores less than 50 μ long.
Urediniospores 24–30 μ; telia hypophyllous. 97. *M. tenella.*
Urediniospores 20–24 μ long; telia epiphyllous..... 97*a*. *M. epiphylla.*
Teliospores more than 50 μ long.
Teliospores broad, averaging more than 18 μ..... 97*b*. *M. Mayorii.*
Teliospores narrow, averaging less than 18 μ..... 98. *M. clara.*
Urediniospore markings tuberculate..... 98*a*. *M. cundinamarcensis.*
Uredinia absent, microcyclic.
Teliospores less than 50 μ long..... 98*b*. *M. Rubi-urticifolii.*
Teliospores more than 50 μ long..... 99. *M. quitensis.*

93*b*. **Mainsia peruviana** Jackson, sp. nov.

O. Pycnia epiphyllous, few, gregarious on yellowish spots, intra-epidermal, forming lenticular cavities in the hypertrophied epidermis.

II. Uredinia epiphyllous, grouped around the pycnia on yellowish spots, often arranged in a concentric manner, tardily naked, becoming pulverulent, long covered by the overarching outer epidermal wall; urediniospores obovate, 18–24 by 30–40 μ; wall colorless, 2–3 μ thick, thickened at apex, 7–10 μ, the prominent sparsely verrucose markings elongated longitudinally; pores obscure.

III. Telia hypophyllous on the yellowish spots bearing the uredinia or scattered, round, whitish, pulvinate; ruptured epidermis not noticeable; teliospores clavate or cylindrical, 16–18

by 44–68 μ, germinating at once; wall uniformly thin, 1 μ or less, colorless; pedicel short, deciduous.

Rubus sp. Valle de Occobainbe, jede Utuma, Peru, Aug. 1922. Coll. Buez *861*, comm. F. L. Herrera.

This very distinct species was sent me by Dr. B. O. Dodge. It is immediately separable from all other *Rubus* rusts of this group by the peculiarly distinct character of the markings on the urediniospore wall. These are in the nature of well separated rounded ridges, very sparsely placed. The ridges are parallel with the long axis of the spore and have a tendency to be arranged in lines. The species was not collected by the Holways.

94. **Mainsia Holwayii** Jackson, sp. nov. (PLATE 11, A–C.)

O. Pycnia epiphyllous, few, gregarious on yellowish spots, intra-epidermal, forming lenticular cavities in the hypertrophied epidermis, 40–45 by 80–100 μ.

II. Uredinia epiphyllous, intra-epidermal, scattered or often arranged in a concentric manner around the pycnia, tardily naked, becoming pulverulent, long covered by the overarching outer epidermal wall; urediniospores obovate, 12–22 by 28–35 μ: wall colorless, 1.5–2 μ, thickened to 3–6 μ at apex, sparsely and rather prominently echinulate, the markings slightly more prominent at the apex; pores obscure.

III. Telia hypophyllous, scattered or gregarious, yellowish, pulvinate, compact, becoming whitish on germination; ruptured epidermis not noticeable; teliospores clavate, 12–16 by 48–70 μ, wall thin, 1 μ or less, colorless, not thickened at apex, germinating at once; pedicel short, colorless.

Rubus floribundus H.B.K. Hacienda "La Florida," Sur Yungas, Bolivia, May 26, 1920. *654* (type). May 28, 1920. *673a*.

Rubus urticaefolius Poir. Chalhuapuguio, Peru, Dec. 8, 1924. F. L. Stevens *216, 222*.

Rubus sp. Hacienda "Anacuri," Nor. Yungas, Bolivia, June 5, 1920. *720, 722*.

A very distinct species characterized by the coarse, sparse, echinulate markings of the urediniospore wall which have little or no tendency to be elongated as in the preceding species. We

have placed tentatively with this species two collections made by F. L. Stevens on *Rubus urticaefolius* in Peru.

94*a*. **Mainsia Pittieriana** (P. Henn.) Jackson, comb. nov.

Uromyces Pittierianus P. Henn. Hedwigia Beibl. **41**: 101. 1902.
Uredo ochraceo-flava P. Henn. Hedwigia Beibl. **41**: 101. 1902.
Spirechina Pittieriana Arth. N. Am. Fl. **7**: 183. 1912.

The characteristic arrangement of the markings of the urediniospore to form a crown at the apex distinguishes this species from all others. It is at present known only from Costa Rica. Specimens from South America in the Arthur herbarium which had been assigned to this species and the next are now referred to elsewhere in this paper.

94*b*. **Mainsia Rubi** (Dietel & Holway) Jackson, comb. nov.

Uromyces Rubi Dietel & Holway; Holway, Bot. Gaz. **31**: 327. 1901.
Spirechina Rubi Arth. N. Am. Fl. **7**: 184. 1912.

This species is now known on several species of *Rubus* from Central America. It has not been reported from South America.

95. **Mainsia Lagerheimii** (P. Magn.) Jackson & Holway, comb. nov.

Uromyces andinus Lagerh. Bull. Soc. Myc. Fr. **11**: 213. 1895. Not *U. andinus* P. Magn. 1893.
Uromyces Lagerheimii P. Magn. Ber. Deutsch. Bot. Ges. **14**: 377. 1896.

Rubus bogotensis H.B.K. Quito, Ecuador, Aug. 13, 1920. *884.*
Rubus floribundus H.B.K. Valle de Chillo, Ecuador, Nov. 13, 1924. F. L. Stevens *289.*
Rubus sp. Cuenca, Ecuador, Sept. 15, 1920. *987*; Guapulo, Ecuador, Nov. 12, 1924. F. L. Stevens *257.*

This species was originally described by Lagerheim from material collected at Quito, Ecuador, on *Rubus* sp. Mayor assigned two collections made in the mountains of Colombia on *Rubus glaucus* (Nos. *101*, *302*) to this species. We have not seen

Mayor's collections but the description fits our material admirably except that Mayor makes no mention of paraphyses. In Holway's No. *987* and in Stevens' collection *257* paraphyses are present in association with the telia. These are inconspicuous and irregular with thin walls evidently peripheral and incurved, 8–12 by 18–25 μ. This species is distinguished from the next by the smaller urediniospores and the more regular and less conspicuous thickening of the wall at the apex of the teliospore.

96. **Mainsia variabilis** (Mayor) Jackson & Holway, comb. nov.

Uromyces variabilis Mayor, Mem. Soc. Neuch. Sci. Nat. **5**: 457. 1913.

Spirechina variabilis Diet. Die Nat. Pflanzenfamilien II auflage **6**: 60. 1928.

Rubus megalococcus Focke. Quito, Ecuador, Aug. 19, 1920. *927*.

Rubus nubigenus H.B.K. Quito, Ecuador, Aug. 19, 1920. *925*.

This characteristic species was based on a collection made by Mayor near Bogota, in Cundinamarca, Colombia (No. *301*). The specimens listed above agree well with the description given by Mayor. *M. variabilis* is close to the preceding species but is separable on account of the large urediniospores and the more evident and irregular character of the thickened wall at the apex of the teliospore. Paraphyses are present in the telia similar to those mentioned in the preceding species.

97. **Mainsia tenella** Jackson & Holway, sp. nov.

O. Pycnia epiphyllous, gregarious on yellowish spots.

II. Uredinia amphigenous, chiefly epiphyllous, on yellowish spots, small, round, 0.4–0.6 mm. across, tardily naked, becoming pulverulent, long covered by the overarching epidermis; urediniospores ellipsoid or obovoid, 15–19 by 24–30 μ, rather variable in length; wall colorless, thin, 1.5–2.5 μ, sometimes slightly thickened at apex, finely and rather sparsely echinulate, the markings slightly more prominent on the upper half of the spore wall; pores obscure.

III. Telia few, hypophyllous, round, compact, whitish; ruptured epidermis not noticeable; teliospores variable, ellipsoid or

obovoid, 14–19 by 28–48 μ, rounded below and usually gradually narrowed above, germinating at once; wall colorless, uniformly thin, 1 μ or less; apical pore not evident; pedicel short, colorless.

Rubus bogotensis H.B.K. Huigra, Prov. Chimborazo, Ecuador, Aug. 2, 1920. *810* (type).

This species is nearest to *Mainsia Rubi* and perhaps to *M. clara*. It is distinguishable from both by the intermediate size of the teliospores. As in the latter, all the uredinia in our specimens occur in association with the yellowish spots bearing pycnia. The few telia that are present are also on these yellowish spots. The teliospores germinate at once and the apical pore is so delicate and undifferentiated that it is often difficult to determine when a spore has started to germinate.

The markings on the urediniospores are only slightly more prominent in the upper half of the spore and on this account the species is given in two places in the accompanying key.

97*a*. **Mainsia epiphylla** (Arth.) Jackson, comb. nov.

Spirechina epiphylla Arth. N. Am. Fl. **7**: 184. 1912.

This species is known only from Texas on *Rubus trivialis*. The teliospores are described as being found in the epidermal cells. According to the interpretation of the writer this is not quite correct. As noted in the discussion of this genus the sori, including pycnia, uredinia, and telia, are often formed in intra-epidermal cavities. The epidermal cells in the vicinity of the sorus are often quite considerably hypertrophied and the sori form as cavities in this hypertrophied region. A careful study of the development of the sori in this genus made from fixed material would be highly desirable.

97*b*. **Mainsia Mayorii** Jackson, nom. nov.

Uromyces quitensis Mayor, Mem. Soc. Neuch. Sci. Nat. **5**: 456. 1913. Not Lagerheim, 1895.

Mayor based his *Uromyces quitensis* on a specimen collected in Colombia on *Rubus* sp. (No. *301a*). Through the courtesy of Dr. R. Thaxter we have been privileged to examine a portion of the type and find Mayor's description reasonably accurate.

We would give the urediniospore measurements 18–20 by 26–30 μ. The wall is 1.5–2 μ thick at the sides, occasionally thickened slightly at the apex to 3–3.5 μ. The markings are verrucose-echinulate and moderately spaced. The teliospores appear all to be germinated as described by Mayor and measure 18–22 by 50–75 μ. The wall is very slightly thickened at the sides near the pore. As explained elsewhere in this paper (No. *99*) we would interpret *M. quitensis* Lagerh. as a lepto-form, and have therefore provided a new name for the species described by Mayor. Mayor included with his species three other collections bearing uredinia only, which we have not seen. This species is closest to *Mainsia clara* (No. *98*) from which it is separable by its broader teliospores, which are slightly thickened at the apex, and the narrower urediniospores, also slightly thickened.

98. **Mainsia clara** Jackson & Holway, sp. nov.

O. Pycnia epiphyllous, few, gregarious on yellowish spots.

II. Uredinia chiefly hypophyllous, gregarious, small, round, tardily naked, pulverulent; ruptured epidermis conspicuous; urediniospores ellipsoid or obovoid, 20–24 by 30–36 μ; wall 2–3 μ thick, colorless, moderately, uniformly, and rather finely, echinulate; pores obscure.

III. Telia hypophyllous, round, 0.5–0.8 mm. across, usually associated with uredinia on yellowish spots, at first somewhat waxy, compact, whitish; ruptured epidermis not noticeable; teliospores obclavate or cylindric, 12–18 by 50–84 μ, rounded below, somewhat narrowed above; wall colorless, 1 μ or less thick, not thickened at apex, smooth; pedicel short, colorless.

Rubus roseus Poir. Sorata, Bolivia, Apr. 18, 1920. *543.*

Rubus sp. Biblian, Prov. de Cañar, Ecuador, Sept. 8, 1920. O, II, III, Holway *963* (type); Cuenca, Ecuador, Sept. 17–24, 1918. O, II, III, J. N. Rose *22832*.

In our specimens of this species, any distinction between primary and secondary uredinia is quite impossible. Most, if not all, of the uredinia seen are on the under side of the yellowish spots which bear the pycnia, but whether they are all primary we have been unable to decide.

The species is readily distinguished from all others by the large, uniformly echinulated urediniospores taken together with the long teliospores and the absence of paraphyses.

We have placed with this species a collection made by Dr. J. N. Rose from the same region, which is in the Arthur herbarium labelled *Spirechina Rubi* (Diet. & Holw.) Arth. It is certainly not that species but agrees well with the one here described, except that the teliospores average somewhat narrower and longer. Another collection made by Rose on *Rubus boliviensis* Focke, at Loja, Ecuador, No. *23270*, is tentatively placed here also. This collection consists of uredinia only and the spores while of the same general type average somewhat smaller than the ones here recorded. The urediniospores in all collections sometimes show a tendency to have the urediniospore markings slightly more prominent at the apex than at the base.

98*a*. **Mainsia cundinamarcensis** (Mayor) Jackson, comb. nov.

Uromyces cundinamarcensis Mayor, Mem. Soc. Neuch. Sci. Nat. **5**: 452. 1913.

Spirechina cundinamarcensis Diet. in E. & P. Nat. Pfl. ed. II. **6**: 60. 1928.

A very distinct species based on a single collection made in Colombia on *Rubus peruvianus* Fritsch (Mayor No. *105*). It is reasonably well described by Mayor. The urediniospore wall is distinctly thickened at the apex and the markings are much more prominent at the apex than at the base. The most prominent distinguishing characters are the long, narrow teliospores and the tuberculate character of the urediniospore markings, especially those at the upper end of the spore. In recording the urediniospore size Mayor evidently did not give sufficient attention to the proper orientation of the spore. Our measurements gave 20–24 by 28–38 μ for the urediniospores and 11–19 by 85–110 μ for the teliospores.

We are tentatively assigning to this species a collection on *Rubus* sp. made near Las Jontas, Ecuador, by Dr. J. N. Rose, Sept. 28, 1918. *No. 23198*. This collection was found in the Arthur Herbarium labeled *Spirechina Pittieriana*. The rust in this collection is certainly closely related to the above, as shown by the character of the urediniospore. Only a few teliospores are present and these are old and germinated. They appear, however, to be considerably shorter and broader than in *U. cundi-*

namarcensis. We hesitate to describe it as new because of the meagre and unsatisfactory character of the material at our disposal.

98*b*. **Mainsia Rubi-urticifolii** (Mayor) Jackson, comb. nov.

Uromyces Rubi-urticifolii Mayor, Mem. Soc. Neuch. Sci. Nat. **5**: 454. 1913.

From Mayor's description one would judge that this species is a lepto-form. It is based on several collections made in the mountains of Colombia on *Rubus urticifolius* by Mayor. We have seen but one of Mayor's specimens. The teliospores are considerably shorter than in the next species (*M. quitensis*).

99. **Mainsia quitensis** (Lagerh.) Jackson & Holway, comb. nov.

Uromyces quitensis Lagerh. Bull. Soc. Myc. France, **11**: 213. 1895.

Rubus bogotensis H.B.K. Quito, Ecuador, Aug. 13, 1920, III. *883*.

Rubus floribundus H.B.K. San Felipe, Sur Yungas, Bolivia, May 19, 1920, III. *617*.

This species was described by Lagerheim from material collected on *Rubus* sp. near Quito, Ecuador, but has not been otherwise reported except by Mayor from Colombia. It was described as a lepto-form and, while we have not seen the type specimen, the two collections listed above conform with the description given by Lagerheim, and one of them is from the type locality. Our specimens are quite certainly short cycled. The telia occur on both the upper and lower surfaces of the leaves on yellowish spots. There are no pycnia.

Mayor assigned four collections which he obtained in Colombia to this species. Mayor's description, however, includes uredinia as well as telia. According to our interpretation Mayor was in error in assigning his collections to *U. quitensis* and we have, therefore, provided a new name for the species as described by him (*M. Mayorii*. No. *97b*).

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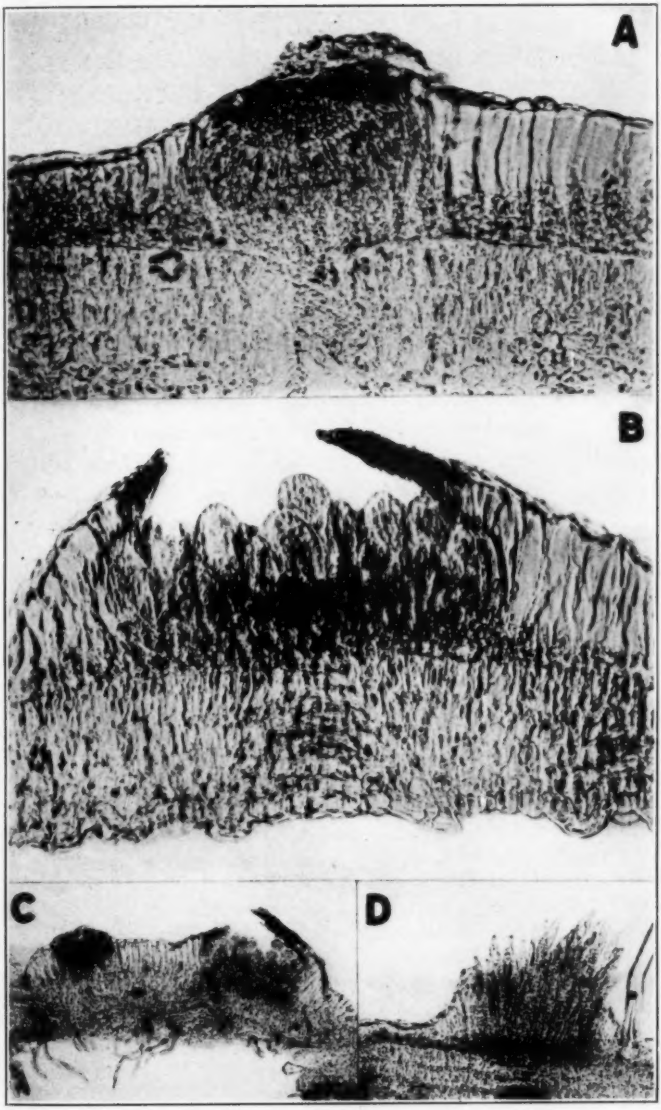
EXPLANATION OF PLATE 11

a, b, c. Mainsia Holwayii. Pycnia and primary uredinia showing relation to hypertrophied upper epidermal cells. *d. Mainsia quitensis.* Showing relation of telia to hypertrophied upper epidermis. Photomicrographs from free hand sections.



MAINSIA HOLWAYII

DIAGNOSES OF AMERICAN PORIAS—III.[1] SOME ADDITIONAL BROWN SPECIES, WITH A KEY TO THE COMMON BROWN SPECIES OF THE UNITED STATES AND CANADA

L. O. Overholts

(With Plates 12–14)

This paper presents descriptions and illustrations of five additional *Poria* species, not previously involved in my reports on this extremely difficult genus. This presentation is followed by a key to some common species of brown *Poria* and resupinate conditions of species of *Trametes*, *Fomes*, and *Polyporus* that are of common occurrence and that are likely to be looked for in the genus *Poria*. Unfortunately there is no known method of distinguishing such resupinate forms of normally pileate species from true species of the genus *Poria*.

Poria ferrea Pers. Myc. Eur. 89. 1825. (Plate 12, Fig. 5; Plate 13, Figs. 10, 12.)

Mucronoporus fulvidus Ellis & Ev. Proc. Phil. Acad. Nat. Sci. **1894**: 323. 1894.

Sporophore perennial only for a maximum of four to five years, effused, sometimes in elliptical patches 5–7 × 2–3 cm., sometimes for several centimeters, in age seeming to loosen from the substratum to some extent, typically with a sterile, cinnamon-colored, fibrillose-tomentose margin that may be quite regular but often irregular and somewhat nodulose; subiculum quite thin though fairly conspicuous in young plants and about 0.5 mm. thick, eventually indistinct; tube layers reaching a total thickness of 0.6–0.8 cm., the tubes 1–3 mm. long each season, whitish within; pore surface cinnamon-brown to dark-brown or sometimes rusty brown, weathering to grayish in age, the mouths subcircular to somewhat angular, thick-walled, entire, averaging 4 to 5 per mm.; spores cylindric, hyaline, smooth, 5–7 × 2–2.5 μ;

[1] Contribution from the Department of Botany, The Pennsylvania State College, No. 74. Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station, as Technical Paper No. 501.

basidia 5–6 μ diameter; setae rather abundant, projecting 10–30 μ beyond the basidia, gradually attenuate to a narrow sharp tip, 5–10 μ diameter at the base; imbedded setal hyphae absent; subiculum hyphae flexuous, reddish-brown in KOH, mostly simple, with no cross walls or clamps, 2–3 μ diameter, a few paler hyphae sometimes with branches and cross walls.

On dead wood of deciduous trees, especially on *Alnus*, but also on *Acer*, *Castanea*, *Quercus*, and perhaps other species.

Specimens examined: Greenwood Furnace and Garner's Run, Huntingdon Co., Pa. (nos. *10747*, *11010*); Emerson, Vermilion, and Stevens, Mich. (nos. *9102*, *5828*, *11769*); Corvallis, Ore. (*11935*); Berkeley, Calif. (type of *M. fulvidus* in The New York Botanical Garden Herbarium).

Though originally described as with globose spores 2 μ diameter, an examination of the type of *M. fulvidus*, of European specimens from Romell, and of collections in my own herbarium shows that they are cylindric as described by Romell.

On small limbs this species has the habit of *P. inermis*, forming elongate or elliptic sporophores that become quite thick for their width, and with age the marginal portion dies, recedes, becomes tumid, and tends to loosen from the substratum. The types of *M. fulvidus* were collected on *Alnus* and that may prove to be its more usual host.

The coloration is rather unusual among species of brown *Poria* which are typically yellow-brown to darker brown. A dark-cinnamon or gilvoid color predominates here.

My interpretation of this species is based on specimens communicated to me by Romell, who reports that they agree with specimens determined by Persoon.

PORIA PRUNICOLA (Murr.) Sacc. & Trott in Sacc. Syll. Fung. **21**: 331. 1912. (PLATE 12, FIGS. 2, 6; PLATE 13, FIG. 8.)

Fomitiporia prunicola Murrill, N. Am. Fl. **9**: 9. 1907.

Sporophore perennial, first appearing in circular patches 1–3 cm. diameter, finally rather widely effused, thin specimens with a tendency to loosen slightly on the margin, otherwise adnate, at first with a narrow yellow-brown or rusty-brown tomentose border that disappears in older specimens; subiculum quite thin, inconspicuous, brown, finally largely disappearing; tube layers

reaching a total thickness of about 1 cm. but usually thinner, the tubes 1–2 mm. long each season, not whitened within except in the old layers, rather indistinctly stratified; pore surface rusty brown to " buffy brown " (Ridgway), becoming somewhat grayish after long weathering, the mouths subcircular, thick-walled, entire, averaging 4 to 6 per mm.; spores broadly ellipsoid or subglobose, smooth, hyaline, 4–5 × 3–4 μ; basidia 4–6 μ diameter; setae present, rather rare, scarcely projecting beyond the basidia, sharp-pointed, 15–20 × 4–6 μ; hyphae brownish-red in KOH, simple, no cross walls or clamps, 3–4 μ diameter.

On dead wood of *Prunus*.

Specimens examined: Medford, Me. (Type in The New York Botanical Garden Herbarium); Crawford Notch, N. H. (no. *4580*); Phoenix, Lewis, Cranberry Lake, N. Y. (nos. *2579*, *7066*, *5857*); Vermilion, Mich. (no. *5827*); in Canada from Winnipeg, Manitoba (no. *7054*).

Some would probably prefer to regard this as a small-spored form of *Fomes igniarius* var. *laevigata*, but young specimens look very different. In old specimens there is a similar whitening of the old tubes as in that species. The small narrow setae and the subglobose hyaline spores on basidia not more than 4–6 μ diameter will separate this species from most of the related brown ones.

PORIA PUNCTATA Fries, Hymen. Eur. 572. 1874. (PLATE 12, FIG. 3; PLATE 14, FIGS. 15, 17.)

Poria Friesiana Bres. Ann. Myc. **6**: 40. 1908.

Fomitiporia laminata Murrill, N. Am. Fl. **9**: 11. 1907.

Poria laminata (Murr.) Sacc. & Trott, Sylloge Fung. **21**: 336. 1912.

Fomitiporia obliquiformis Murrill, N. Am. Fl. **9**: 9. 1907.

Sporophore perennial, effused for several centimeters, never loosening from the substratum, sometimes cracking on drying, young specimens with a rather distinct yellow-brown tomentose margin that mostly disappears with age; subiculum a thin brown inconspicuous membrane that largely disappears in old plants; tube layers reaching a total thickness of 1.5 cm., the tubes 1–3 mm. long each season, soon stuffed with a rusty gray or gray mycelium, the annual layers separated by distinct though extremely narrow layers of subiculum so that the region is distinctly though inconspicuously stratified; pore surface yellow

brown to "buffy-brown" or "Saccardo's umber" (Ridgway), the mouths circular to sub-circular, thick walled, entire, averaging 6 to 8 per mm.; spores globose or subglobose, smooth, hyaline, 5–8 μ diameter; basidia much inflated, 7–10 μ diameter; setae none; cystidia (?) usually abundant as finely attenuate hyaline hyphae less than 2 μ diameter, enlarged to bulbous or inflated bases, projecting 10–30 μ; hyphae long and flexuous, brown, no cross walls or clamps, diameter 2–4 μ.

On dead wood of deciduous trees; noted on *Acer*, *Alnus*, *Asimina*, *Betula*, *Carpinus*, *Cephalanthus*, *Fraxinus*, *Maclura*, *Ostrya*, *Oxydendrum*, *Pyrus*, *Robinia*, *Quercus*, and *Salix*, with particular preference for *Salix*.

Specimens examined: Piscataquis Co., Me. (Type of *P. laminata* in The New York Botanical Garden Herbarium); Lake Winnipesaukee, N. Conway, and Temple, N. H. (nos. *5957*, *5169*, *9051*); Syracuse, Norwich, Silver Lake, and Ithaca, N. Y. (nos. *5825*, *8053*, *8051*, *3973*); Detwiler Run, Huntingdon Co., Pa. (no. *9732*); Morgantown, W. Va. (no. *7132*); Clark Co., Ga. (no. *9571*); Berea, Ky. (no. *9270*); Oberlin, Ohio (no. *8539*); Weirtown and Turkey Run State Park, Ind. (no. *3928*, *11810*); Hillsboro, Ill. (no. *9162*); Dexter (2), New Richmond, Ann Arbor (2), and Whitmore Lake, Mich. (nos. *9090*, *9155*, *9156*, *8658*, *9159*, *8660*); Balsam Lake, Wis. (no. *9053*); Rush City, Minn. (no. *7065*); Meramec Highlands (2), Wicks (2), Creve Coeur Lake, Perryville (3), and Jefferson Barracks, Mo. (nos. *5721*, *2571*, *2865*, *2586*, *5710*, *2964*, *2691*, *2737*, *5729*); in Canada, from Winnipeg, Manitoba (no. *6152*), and Edmonton, Alberta (no. *12095*).

This species seems to be common where extensive collections have been made from New Hampshire to Wisconsin and Missouri. The early American mycologists referred it to *Fomes salicinus* and *Poria obliqua*, for the most part. Bresadola states that in Europe it was known as var. *resupinatus* of *Fomes igniarius*, and as *Poria contigua*. While it may be *P. contigua* of Fries, it is very improbable that it is *P. contigua* Pers. from which, as well as from *P. ferruginosa*, *Trametes tenuis* and related species, it differs in the lack of setae. Bresadola on this point says that in European specimens (discussed as *P. Friesiana* Bres.) setae are very rare and in a specimen from Romell I find some setae

present. I have sectioned numerous American collections, however, without finding a trace of setae. Otherwise the species is characterized by the plainly laminated hymenial region, the globose spores, the large basidia, and the numerous cystidia-like organs usually present in the hymenium. When one compares first-year stages with those several years old, they appear very different, but a large series of specimens renders these differences of no taxonomic value. Murrill describes *P. obliquiformis* as not having tubes definitely stratified; yet his specimens scarcely justify this statement. Hence I am referring to this species all collections with definitely stratified tubes soon whitish within, with globose spores 5–8 μ diameter, large basidia 7–10 μ diameter, and an entire lack of setae (in American specimens). The cystidia-like bodies usually present in the hymenium may not be of diagnostic value. In old specimens the margin gradually recedes and the outermost portions often become blackish or dark gray with age.

PORIA TSUGINA (Murr.) Sacc. & Trott in Sacc. Syll. Fung. **21**: 332. 1912. (PLATE 12, FIG. 4; PLATE 14, FIGS. 14, 16.)

Fomitiporia tsugina Murrill, N. Am. Fl. **9**: 9. 1907.

Sporophore perennial, rather widely effused, adnate to the substratum, the first year with a rather broad thin sterile rusty-yellow margin, this less conspicuous in succeeding years until it entirely disappears, the margin finally thicker and darker in color; subiculum as a thin brown membrane not more than 1 mm. thick; tube layers reaching a total thickness of 6 cm., but often 1 cm. or less, the tubes 4–8 mm. long each season, rather distinctly stratified, typically golden-brown where cut vertically but somewhat grayish within, especially in age; pore surface dark golden-brown or tawny to dark grayish-brown, the mouths subcircular to subangular, thick-walled, entire, typically averaging 6 to 8 per mm., sometimes somewhat larger; spores globose or subglobose, smooth, hyaline, 5–7 μ diameter; basidia inflated, 8–10 μ diameter; setae none; hyphae brown, simple, no cross walls or clamps, diameter 2.5–3.5 μ diameter.

On dead wood of coniferous trees; noted on *Picea*, *Pinus*, and *Tsuga*.

Specimens examined: Hebron, Lisbon, and N. Conway, N. H. (Type in The New York Botanical Garden Herbarium, and nos.

5091, 4962); Jamesville, Phoenix and Vaughns, N. Y. (nos. *3223, 2575, 4788*); Laurel Run, Reitz Gap, Stone Valley (2), Shaver's Creek, and Warriors Mark, Pa. (nos. *11004, 5439, 5991, 5893, 7331, 6078*); New Brunswick (2), N. J. (nos. *5674, 7850*); Lorain Co., Ohio (no. *9783*); Eldora, Colo. (no. *9167*); Priest River, Ida. (no. *4516*); Multnomah Co., Ore. (no. *7135*); Requa and Korbel, Cal. (nos. *9052, 4719*).

In Pennsylvania this is a rather frequent species, usually on *Tsuga* logs. It frequently has the habit of growing on the lower side of limbs 2 or 3 inches diameter on dead snags, and often where the dead branch joins the trunks. In such situations, after a few years of growth with the unusually long tubes it has somewhat of a pendant appearance as shown in Plate 14, figure 14. However it is frequently found on the lower side of large fallen logs.

In one collection I have noted a trace of a pale brown coloration in the walls of the spores, but otherwise they are hyaline.

Perhaps the species is too closely allied to *Fomes robustus* as indicated by the typical bright brown or golden brown color within, the long tubes fairly well stratified, the minute pores, the large basidia, large globose spores 6–8 μ diameter, and the lack of setae.

PORIA WEIRII Murrill, Mycologia **6**: 94. 1914. (PLATE 12, FIGS. 1, 7; PLATE 13, FIGS. 9, 11, 13.)

Fomitipoŕia Weirii Murrill, Mycologia **6**: 93. 1914.

Sporophore perennial for a maximum of five or six years, light of weight and soft of texture when compared with most perennial species, effused for several centimeters, separating rather readily from the substratum, the first year's growth with a broad (1–2 mm.) fibrillose, sterile margin of which, due to irregularities of growth, little remains in older plants; subiculum brown, soft, punky, usually only 1–2 mm. thick but thicker at times due to irregularities in the substratum; tube layers reaching a total thickness of 2 cm. but often less than 1 cm., the tubes 2–4 mm. long each season, not at all whitened within, the annual layers separated by a thin soft subicular membrane and easily loosening from each other; pore surface dark umber brown to dark rusty-brown, the mouths angular, at maturity very thin walled but entire, averaging 5 to 6 per mm.; spores globose or subglobose,

smooth, hyaline, 4–6 μ diameter; setae usually very abundant, projecting very conspicuously, tapering to a sharp point, usually somewhat incrusted, 6–12 μ diameter, and readily seen to be the termini of large brown imbedded hyphae; imbedded setal hyphae rather numerous in the walls of the tubes, 6–12 μ diameter; hyphae of the subiculum thin walled, sparingly branched, with rather abundant cross walls, no clamps, the branches originating at a point median between two adjacent cross walls, 2.5–6 μ diameter.

On coniferous wood, perhaps largely or entirely confined to *Thuja plicata*.

Specimens examined: Priest River and Upper Priest River, Idaho (nos. *3927*, *11842*, *3525*, *11886*, *11883*); Waltersville, Ore. (no. *8208*).

Although a large series of specimens have been examined from the northwest, this species has appeared but once except in Idaho collections.

It is a well marked species with its light weight, spongy consistency, the separating annual tube layers, and above all in the peculiar setae that are found in very few other American *Poria*. The major portion of the tube walls is made up of large setal hyphae 6–12 μ diameter at their tips. Some of these tips are imbedded in the tissue of the walls but most of them curve into the hymenial layer and become the projecting setae of that region. The ordinary hyphae of the subiculum and the walls are also quite characteristic in their thin exterior walls, with rather numerous cross walls, no clamps, and the branches originating at a point midway between two adjacent walls.

In connection with the original description, Murrill recorded some notes from Weir to the effect that the species is at times parasitic on *Thuja plicata* and is at any rate an important timber decaying organism.

A KEY TO THE COMMON BROWN SPECIES OF PORIA IN THE UNITED STATES AND CANADA

The study of the various species of *Poria* may be much facilitated when all are correctly known, but their accurate identification will always be a problem to tax the keenest mycological student. At the present time we are not sure just which char-

acters are reliable and which ones subject to too much variation to be reliable for specific identification. We are certain that great reliance, here as in other fungi, can be placed on the spores produced on the basidia. In the brown species the presence or absence of setae and the form of these organs are of considerable importance. The size of the basidia affords an item of diagnostic value not hitherto recognized. One section of brown species has basidia 8–10 μ in diameter, and consequently they are conspicuous when the sporophore is in fruiting condition. Another section has small basidia 3–6 μ in diameter. Large globose spores 6–8 μ diameter are correlated with basidia of large diameter, and small globose or cylindric spores with basidia of small diameter. In most species the hyphae that make up the sporophore are not highly characteristic, but in a few cases the lack of thickened hyphal walls and the presence of cross walls in the hyphae are great aids in specific diagnoses. Of superficial characters that pertain to brown species, probably in general the less reliance that is placed on them the better. A distinction into annual and perennial forms can be made but is often misleading. The extent to which definite layering of tubes is present in perennial forms is of some importance; the thickness of the sporophore produced is of less value. Substratal habitats often give a clue to identification but may be misleading.

Thus it is evident that the leading characters on which species may be based are mainly microscopic. This is to be expected in a genus in which the sporophore is without pileus or stem. The same situation faces the student of any group of resupinate Basidiomycetes. Therefore, it is useless to attempt identification without recourse to free-hand sections of the tubes, preferably cut crosswise to the long axis of the tubes. The thinner these sections can be made, the better. Mounting in lactic acid is often preferable to mounting in KOH, which causes the sections to become very dark.

No species are regarded as belonging to the section of the true brown *Poria* unless they show a characteristic darkening or blackening when the sections are immersed in KOH or when KOH solution is applied directly to the tubes. Further, I have included in the following key the species of *Polyporus*, *Fomes*,

and *Trametes* that are likely to be found in a resupinate condition. The key is followed by a list of the brown species so far presented in my various papers on this genus, together with page references to the descriptions already presented. Many collections yet remained unnamed in my herbarium, and a number of other species have been described from this area. Hence the following key is offered only as a summary of facts relating to the species that now seem to stand out as distinct and at the same time as rather common members of our flora.

1. Setae absent when cross-sections of the tubes are examined..... 2
   Setae present though not necessarily abundant in cross-sections of the tubes..... 6
2. Growing only on wood of coniferous trees..... 4
   Growing only on wood of deciduous trees..... 5
3. Growing only on charred wood..... *Trametes carbonaria.*
   Not growing on charred wood..... 4
4. Sporophore thin, soft, and pliant, separating from the very rotten substratum as a thin pliant sheet; tubes rarely stratified in two or three layers; spores ellipsoid to subglobose, 5–7 × 3–5 μ; hyphae of subiculum thin-walled, 5–7 μ diameter, with frequent cross walls; mouths of the tubes averaging 1 to 2.5 per mm..... *P. subiculosa.*
   Sporophore leathery to woody, not pliant, and not so separating; tubes not distinctly stratified; spores cylindric, 9–12 × 3–5 μ; hyphae of subiculum 3–6 μ diameter, without cross walls; mouths of the tubes averaging 2 to 3 per mm..... *Trametes odorata.*
   Sporophore woody, soon 1 to several centimeters thick, not separating; tubes in distinct annual layers; spores globose, 6–7 μ diameter; hyphae of subiculum without cross walls, 2.5–3.5 μ diameter; mouths of the tubes averaging 6 to 8 per mm..... *Poria tsugina.*
5. Spores brown, 4–5 μ diameter; tubes not stratified; pores averaging 3 to 4 per mm.; basidia 5–6 μ diameter; usually on *Ilex* or *Nemopanthes*. *P. inermis.*
   Spores hyaline, 5–8 μ diameter; tubes more or less distinctly stratified; pores averaging 6 to 8 per mm.; basidia 7–10 μ diameter; not on *Ilex* or *Nemopanthes* but on a great variety of other hardwoods. *P. punctata.*
6. Growing on wood of coniferous trees..... 7
   Growing on wood of deciduous trees..... 10
7. Plants showing one of the following sets of characters:
   A. With large brown setal hyphae 6–12 μ diameter making up most of the tissue of the walls of the tubes[2] and ending in large protruding hymenial setae (see fig. 9 of this paper)..... 8
   B. As in the above but setal hyphae less conspicuous, only 4–6 μ diameter; hymenial setae not incrusted.. *Polyporus glomeratus.*
   C. Setae lanceolate, projecting 25–60 μ beyond the basidia; no imbedded setal hyphae; spores cylindric..... *Trametes tenuis.*

[2] Best seen in thin longitudinal sections of the tubes.

D. With a narrow black line in the subiculum (conjust) text below the tube layer; no setal hyphae; setae projecting less than 25 μ beyond the basidia; spores cylindric. *Fomes nigrolimitatus.*

Plants not fitting well into any of the above 9

8. Sporophore truly perennial, the annual tube layers separated by a thin subicular membrane and easily loosening from each other; spores globose, 4–6 μ diameter ..... *Poria Weirii.*

Sporophore sometimes perennial for two or three seasons, the tubes not layered and not separating; spores cylindric, 3–5 × 1–2 μ. *P. ferrugineo-fusca.*

9. Setae 6–7 μ diameter at base; pores averaging 5 to 7 per mm. *Fomes putearius.*

Setae 9–15 μ diameter at base; pores averaging 3 to 5 per mm. *Fomes Pini.*

10. Sporophore annual or rarely reviving a second season 11

Sporophore truly perennial with downward extension of the tubes year by year 13

11. With imbedded setal hyphae (as under 7*A*) ..... *Polyporus glomeratus.*

Without such imbedded setal hyphae 12

12. Pores averaging 6 to 8 per mm.; spores 4–6 × 2.5–3.5 μ; setae projecting less than 25 μ ..... *Polyporus gilvus.*

Pores averaging 4 to 6 per mm.; spores 4–6 × 2.5–3.5 μ; setae projecting less than 30 μ ..... *Poria ferruginosa.*

Pores averaging 1 to 3 per mm.; spores 6–7 × 2–2.5 μ; setae projecting 25–60 μ ..... *Trametes tenuis.*

13. Growing only on *Prunus* 14

Growing on other substrata 15

14. Hyphae with cross walls as seen in crushed mounts, diameter 3–6 μ; setae 6–8 μ diameter; chiefly on *Prunus* species of the plum group. *Fomes fulvus.*

Hyphae without cross walls, diameter 3–4 μ; setae 4–6 μ diameter; chiefly on *Prunus* species of the cherry group ..... *Poria prunicola.*

15. Pores averaging 4 to 5 per mm.; spores cylindric, 5–7 × 2–2.5 μ. *Poria ferrea.*

Pores averaging 4 to 5 per mm.; spores globose, hyaline, 5–6.5 μ diameter. *Fomes igniarius* var. *laevigatus.*

Pores averaging 6 to 8 per mm.; spores hyaline, 4–5 × 3–4 μ. *Fomes conchatus.*

Pores averaging 8 to 10 per mm.; spores pale rusty, 3–3.5 μ diameter. *Fomes densus.*

LIST OF COMMON SPECIES OF BROWN PORIA, WITH SOME SYNONYMY, AND WITH REFERENCES TO DESCRIPTIONS IN PREVIOUS PAPERS

BETULINA (PORIA). A synonym for *Fomes igniarius* var. *laevigatus* Fries.

CARBONARIA (TRAMETES). Originally described as *Hexagonia* (Grevillea 1: 68. 1872). Described by Murrill (N. Am.

Fl. **9**: 4. 1907) as *Fuscoporia*. Known from N. Y., S. Car., Idaho, Mont., Oreg., and Calif. Usually on charred *Sequoia* logs in the west. Occasionally pileate, hence not a true *Poria*. *T. Sequoiae* Copeland is a synonym. Not previously described in this series.

CONCHATUS (FOMES). Rarely occurs entirely resupinate, usually with some indication of a pileus. Described in all the manuals. Ranges from Maine to Florida and west to Montana and Texas. Also in Canada. On a variety of hardwoods, never on conifers.

DENSUS (FOMES). A species described by Lloyd (Synopsis of Genus *Fomes* 245. 1915). Previously referred to *F. conchatus*. Usually resupinate. Known from Ohio, Indiana, Missouri, and Iowa. On hardwood logs. Not described in this series of papers.

FERREA (PORIA). A true *Poria*. *P. fulvida* Ellis & Ev. is a synonym. See p. 117 of this paper.

FERRUGINEO-FUSCA (PORIA). A true *Poria*. *P. marginella* (Peck) Sacc. is a synonym. See N. Y. State Mus. Bull. 205–206: 88. 1919.

FERRUGINOSA (PORIA). A true *Poria*. See Mycologia **14**: 5. 1922. *P. Macounii* Peck is a synonym.

FULVIDA (PORIA). A synonym for *P. ferrea* Pers., which see.

FULVUS (FOMES). Rarely occurs entirely resupinate. Described in all the manuals. Ranges from Maine to Alabama and west to Montana. On species of *Prunus* belonging to the plum section.

PINI (FOMES). Occasionally occurs nearly or quite resupinate. Described in all the manuals. On coniferous wood only. Ranges throughout the United States and Canada.

PRUNICOLA (PORIA). A true *Poria*. See p. 118 of this paper.

PUNCTATA (PORIA). A true *Poria*. See p. 119 of this paper. *P. laminata* Murrill and *P. obliquiformis* Murrill are synonyms.

PUTEARIUS (FOMES). Usually occurs more or less resupinate. Originally described by Weir in Jour. Agr. Res. **2**: 163. 1914, but spores are hyaline, 4–5 × 3–4 μ (not "colored, 7–8 μ"). On coniferous woods only. Known only in Idaho, Montana, Oregon, and Washington.

SEQUOIAE (TRAMETES). A synonym for *T. carbonaria* Berk. & Curt., which see.

SETIGERA (PORIA). Probably a young stage of *Polyporus glomeratus* Peck. See Bull. N. Y. State Mus. 205–206: 109. 1919.

SETOSUS (TRAMETES). A synonym for *T. tenuis* Karst., which see.

SUBICULOSA (PORIA). A true *Poria*. See Bull. N. Y. State Mus. **205–206**: 115. 1919.

SUPERFICIALIS (PORIA). A synonym for *T. tenuis* Karst., which see.

TENUIS (TRAMETES). Usually occurs entirely resupinate. *T. setosus* Weir (Jour. Agr. Res. **2**: 164. 1914), *P. superficialis* (Schw.) Cooke, and *P. viticola* (Schw.) Cooke are synonyms. See also Mycologia **15**: 224, 225. 1923, for descriptions.

TSUGINA (PORIA). Probably a true *Poria*. See p. 121 of this paper.

VITICOLA (PORIA). A synonym for *T. tenuis* Karst., which see.

WEIRII (PORIA). A true *Poria*. See p. 122 of this paper.

STATE COLLEGE, PENNA.

EXPLANATION OF PLATES

PLATE 12

Fig. 1. *Poria Weirii*. Hyphae from the subiculum, to show prevalence of cross walls and manner of branching. No. *3927*. × 820.

Fig. 2. *Poria prunicola*. Camera lucida sketch to show prevalence of setae in the hymenium. From type specimen. × 170.

Fig. 3. *Poria punctata*. Drawing of small portion of the hymenium to show basidia, spores, and the characteristic cystidia-like organs usually present. No. *8658*. × 820.

Fig. 4. *Poria tsugina*. Drawing of small portion of the hymenium to show basidia and spores. No. *5893*. × 820.

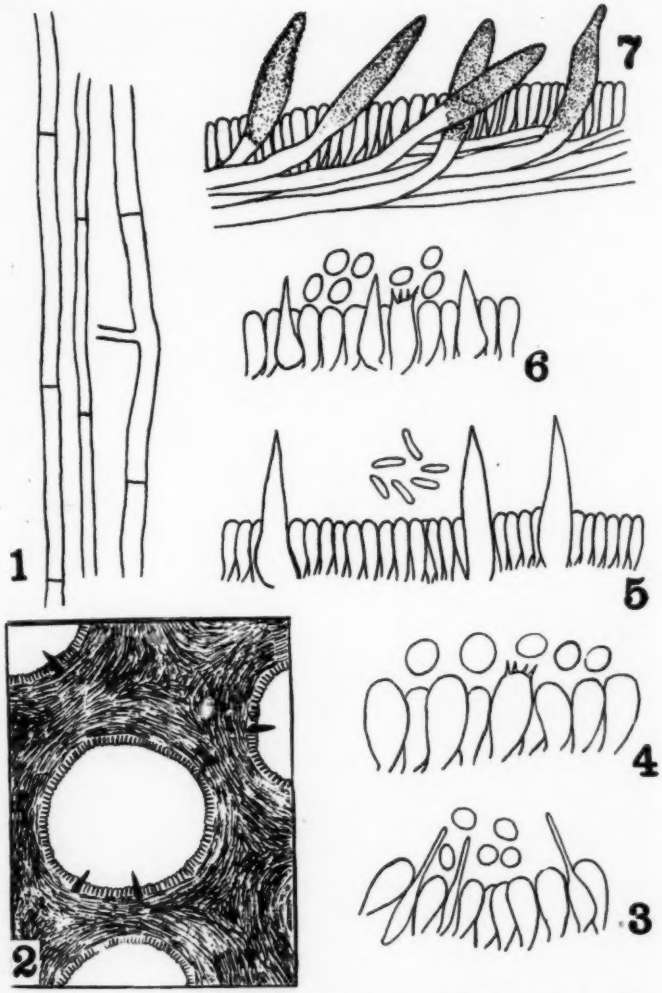
Fig. 5. *Poria ferrea*. Drawing of small portion of the hymenium to show basidia, setae, and spores. No. *10747*. × 820.

Fig. 6. *Poria prunicola*. Drawing of small portion of the hymenium to show basidia, setae, and spores. From type specimen. × 820.

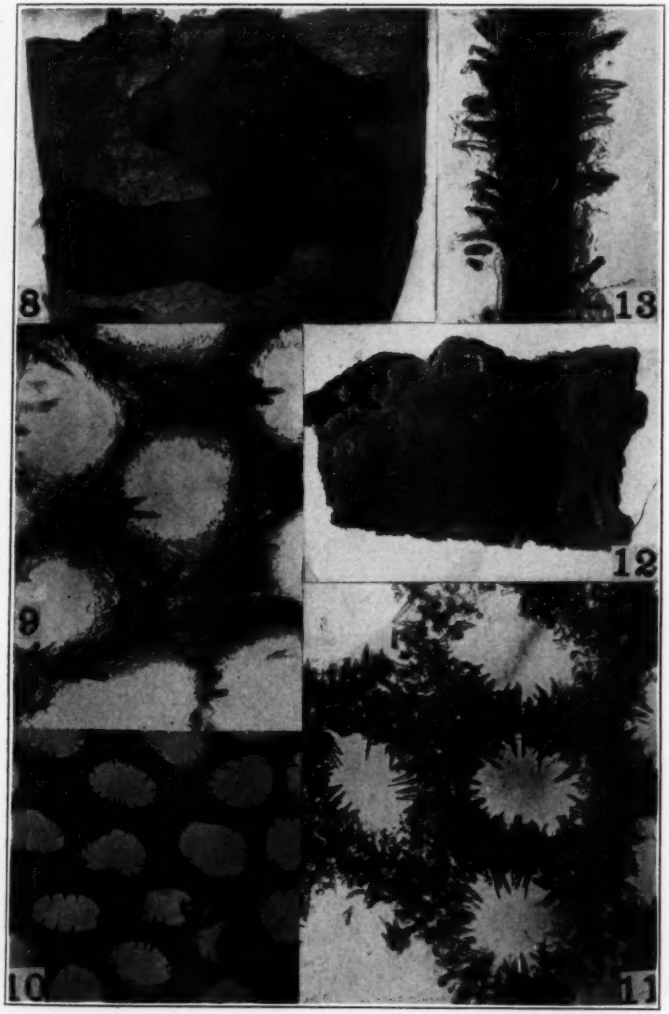
Fig. 7. *Poria Weirii*. Drawing of small portion of the hymenium to show the incrusted setae and their origin at the tips of large hyphae that extend into the trama of the tubes. No. *3927*. × 820.

PLATE 13

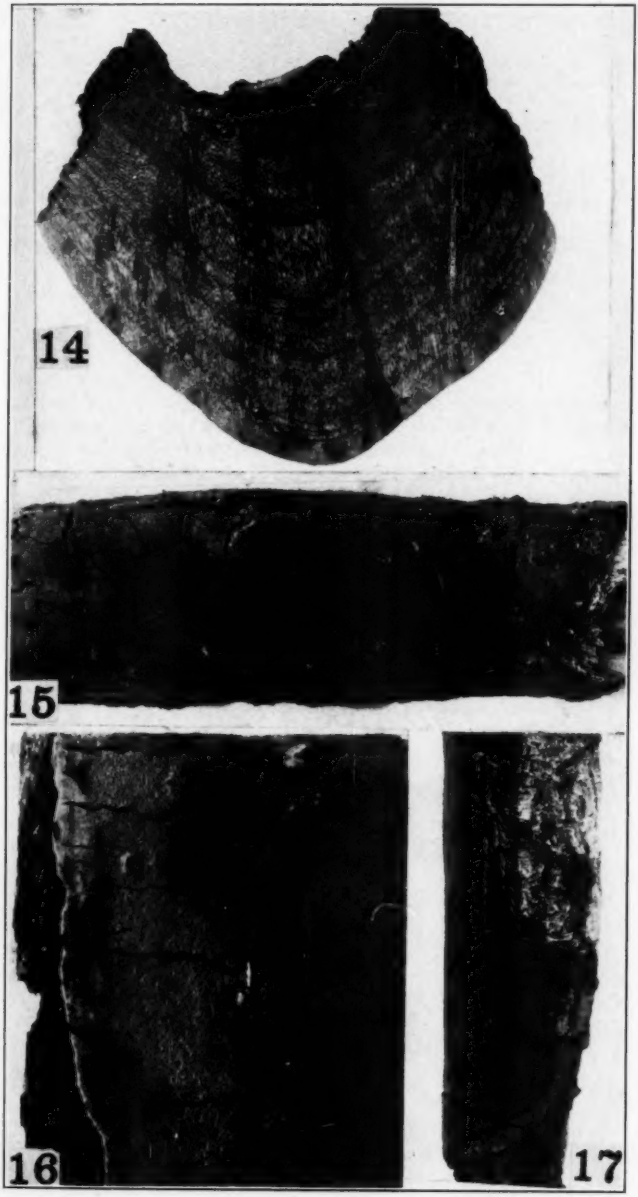
Fig. 8. *Poria prunicola*. Photo of typical specimens in first year's growth. No. *4580*. × 1.



1, 7. *Poria Weirii;* 2, 6. *Poria prunicola;* 3. *Poria punctata;* 4. *Poria tsugina;* 5. *Poria ferrea.*



8. *Poria prunicola;* 9, 11, 13. *Poria Weirii;* 10, 12. *Poria ferrea.*



14, 16. *Poria tsugina;* 15, 17. *Poria punctata.*

Fig. 9. *Poria Weirii.* Photo-micrograph of cross section of tubes, showing the setal hyphae imbedded in the walls of the tubes and some projecting into the lumen of the tubes. No. *3927.* × 170.

Fig. 10. *Poria ferrea.* Photo-micrograph of cross section of the tubes, showing abundance of setae. Type of *P. fulvida.* × 60.

Fig. 11. *Poria Weirii.* Photo-micrograph of cross section of the tubes, showing abundance of setae projecting into the lumen of the tubes. No. *3927.* × 150.

Fig. 12. *Poria ferrea.* Photo of specimen from L. Romell. No. *11869.* × 1.

Fig. 13. *Poria Weirii.* Photo-micrograph of small portion of one tube wall in longitudinal section, showing the projecting setae curving out from the trama of the wall. No. *3927.* × 170.

PLATE 14

FIG. 14. *Poria tsugina.* Photo of vertical section through a sporophore 12 to 15 years old, pendant from the lower side of a branch of *Tsuga.* The annual tube layers are fairly distinct. No. *5893.* × 1.

FIG. 15. *Poria punctata.* Photo of typical specimen. No. *8658.* × 1.

FIG. 16. *Poria tsugina.* Photo of a thinner specimen from the lower side of a prostrate log. No. *4516.* × 1.

Fig. 17. *Poria punctata* Fries. Photo of specimen partially cut away to show the very apparent tube layers. No. *9051.* × 1.

NOTES ON IOWA SPECIES OF THE GENUS IRPEX

K. Cejp

(With 1 Text Figure)

The genus *Irpex* Fries is one of the most interesting of the genera of the Hymenomycetes, especially with reference to its systematic position. Most mycologists place it in the family Hydnaceae because of the teeth upon which the hymenium is borne. In time, however, these teeth unite in rows and in various comb-like, labyrinthiform patterns until they sometimes assume the appearance of species of *Lenzites* or *Daedalea*. In addition, the general consistency of its hymenium and its microscopic features require that this genus be placed in the family Polyporaceae, as is done by Quélet [1] and by Bourdot and Galzin.[2]

Most of the species referred at the present to this genus were included by Patouillard in the genus *Coriolus*. Some, such as *I. deformis*, *I. obliquus* and *I. paradoxus*, are usually considered as forms of *Poria mucida* Pers. (**1**).

The largest number of the species of *Irpex* are included in the section Resupinati in which the receptacle is effused on the substratum. Because of their slight morphological difference these species are rather poorly understood. The European species of this section were subjected to a revision by Pilat (**2**) chiefly on the basis of material from Bohemia collected by Velenovský (**5**).

In this paper I refer to certain species of the genus *Irpex* from Iowa which I received through the kindness of Mr. G. W. Martin. Some of these species are very rare; some have not as yet been found in Europe. The most abundant species of the Iowa collection was *Irpex lacteus* Fries. Saccardo (**4**) distinguishes four sections in the genus *Irpex*, according to the presence or absence of a stem and the shape of the hymenium. The species from Iowa are to be referred to his last two sections.

[1] Flore Myc. Fr. 376. 1888.

[2] Bull. Soc. Myc. Fr. **41**: 148. 1925.

SESSILES VEL EFFUSO-REFLEXI MARGINATI

Irpex lacteus Fries, Elench. Fung. **1**: 145. 1828.

Effused, at the borders shortly reflexed, cortical, often roof-shaped, concentrically sulcate, villose, white, at the margins byssoid. Teeth arranged in rows, dense, flat, often compressed, thin, sharp, sometimes subdivided, milk-white, later ochraceous. Spores ovoid-globose, 2×4–$6\ \mu$.

Distribution: North America, Asia (Siberia), Europe (England, France, Russia). In Abiete in Europa etiam in America arctica (Klotsch), ad truncos arborum pr. Minussinsk Siberiae asiaticae, ad ramos et truncos emortuos arborum frondosarum Forestburg, New York, Amer. foeder., ad *Quercus* in Carol., inf. (Saccardo **6**: 484). On birch, fir, pine, beech and mountain ash (Rea, **3**).

On *Quercus macrocarpa*, West Okoboji, June 15, 1926, Lohman, Longnecker and Martin; on decayed limb of *Quercus*, Iowa City, October 14, 1923, G. W. Martin; Iowa City, September 30, 1923, M. N. Baird and G. W. Martin; West Okoboji, August 17, 1926, G. W. Martin.

Irpex hirsutus Kalchbrenner, Sziber. Gomb. 17, t. II, f. 1.

Effused, often imbricated, shaggily villose, white. Teeth fairly large, almost foliated, irregularly arranged, yellowish, never white. Very similar to the species *Irpex lacteus* Fries. Rare.

Distribution: Hungary, Siberia. On trunks of deciduous trees.

On *Quercus*, Iowa City, October 15, 1923, G. W. Martin.

Irpex griseofuscus Mont. Syll. Crypt. 174. 1856. (Saccardo **6**: 487.)

Coriaceous-membranaceous, often semicircular, on the surface semicircularly sulcate, with light or darker stripes; dense, short, grayish-brown, shaggy hair. Teeth either awl-like and short, or labyrinthiformly connected, dense, sometimes almost lamelliformly connected, light brown, white pruinous, at the base reticulately connected. Very rare.

Distribution: Known only from the northern part of South America (Guiana, Leprieur).

On fallen *Acer*, Black Hawk County, Iowa, August 10, 1925, G. W. Prescott; Iowa City, October 6, 1923, G. W. Martin.

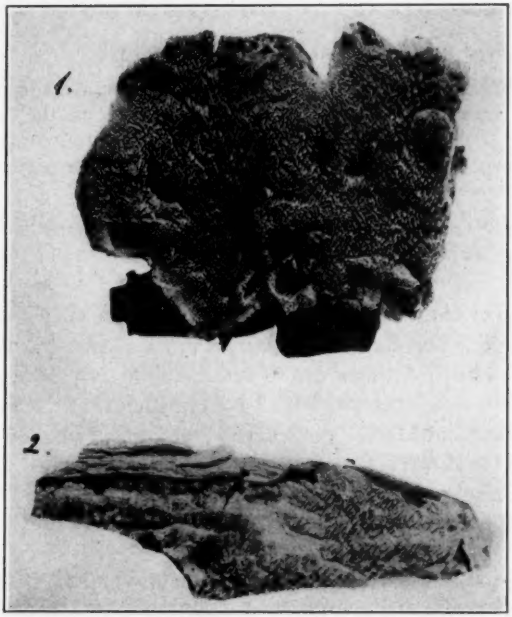


FIG. 1. *Irpex hirsutus* Kalchb. 2. *Irpex obliquus* (Schrad.) Fries.

RESUPINATI

Irpex obliquus (Schrad.) Fries, Elench. Fung. 1: 147. 1828.

Frequent in Europe and North America (Peck). In Europe frequently collected and described (Fries, Bresadola, Massee, Rea, Quélet, Schroeter, Killermann, Velenovsky, Pilat).

Iowa City, October 6, 1923, G. W. Martin.

Irpex fimbriaeformis Berk. & Curt.; Berk. Grevillea 1: 145. 1873.

Totally effused on the substratum, not raised, margin indistinct, pale. Teeth arranged in rows, enlarged at the base. elongated above, yellowish brown. Very rare.

Distribution: Pennsylvania, Amer. foeder., Michener (Saccardo).

On *Quercus*, Homestead, Iowa, May 10, 1925, F. S. Paine.

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THE ASCIGEROUS STAGE OF COLLETOTRICHUM LAGENARIUM INDUCED BY ULTRA-VIOLET IRRADIATION

F. L. Stevens

(With 3 Text Figures)

Colletotrichum lagenarium (Pass.) Ellis & Hals.

This was first described by Passerini in 1867 [1] as a *Fusarium* and what may have been the same fungus was seen by Berkeley in 1871–76 on various cucurbits.[2]

It was also seen by Roumeguère in 1880 [3] who on the advice of Saccardo transferred it to the genus *Gloeosporium*. It was listed in America in 1885.[4] The presence of setae in the acervuli was first noted in 1889 and in 1893 Ellis and Halsted gave to the fungus its present name.[5]

It is now known in Italy, England, France, Australia, America, and, being the cause of a disease of serious economic importance, it has many times been the subject of observation and extensive study. Although sixty-two years have elapsed since the first record of this fungus, during which time many mycologists in many countries have observed, studied and cultured it and always with close observation for the perithecial stage, no one has heretofore succeeded in finding such stage.

Perithecia, however, have been produced abundantly by irradiation [6] with ultra-violet, and only by this means, upon two strains of *C. lagenarium*, one my own isolation from melons

[1] Passerini, G. See Centralbl. Bak. II. **44**: 123. 1915.

[2] Berkeley, M. J. Gard. Chron. **1871**: 1194. 1871; II. **6**: 269. 1876.

[3] Roumeguère, C. Nouvelle apparition en France du *Gloeosporium* (*Fusarium*) *reticulatum* Mt. destructeur des melons. Rev. Myc. **2**: 169–172. 1880.

[4] Ellis, J. B., & Everhart, B. N. The North American species of *Gloeosporium*. Jour. Myc. **5**: 118. 1885.

[5] Ellis, J. B., & Halsted, B. D. Bull. Torrey Club **20**: 246–250. 1893.

[6] For other papers on ultra-violet irradiation by the author, see Science, III. **68**: 1923, and Bot. Gaz. **86**: 210. 1928.

grown here, the other a strain isolated in Georgia and sent to me by Dr. B. B. Higgins.

The almost universal manner of their appearance is as follows: Very shortly after irradiation, twenty-four hours or less, the entire irradiated region of the colony is considerably darker than that of the non-irradiated region and then or very soon certain

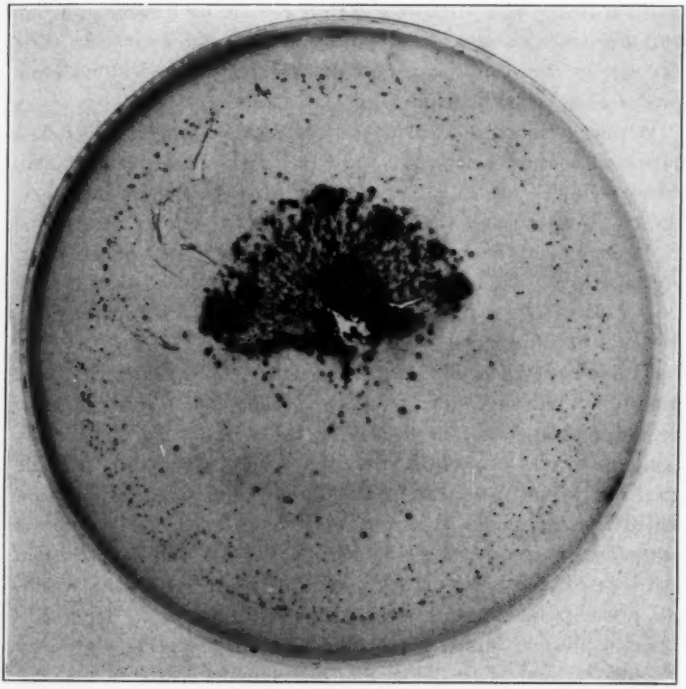

FIG. 1. *C. lagenarium* isolated from melon at Urbana. Many black perithecial plexi shown, immersed on the irradiated half of the plate.

areas stand out as especially dark regions due to large increase in both the density and color of the mycelium in these regions which I shall hereafter refer to as " plexi " (FIG. 1). These are so dense and dark as to be opaque except at the edges. A usual size is 230 μ in diameter for the central dense region, or 800 μ in

diameter if all the darkened region is included. There is, however, no regularity as to size or density of the plexi. They are sometimes two or three times the diameter indicated above and sometimes even though large may be less dense or dark. Sometimes the dense plexi are evidenced merely by a very slight increase in density and color in a given region. No plexi appear in the nonirradiated area. Later the perithecia increase in number in the plexus though always remaining loosely grouped and with no stromatic development. Still later perithecia may develop in the open space between plexi, but then in no such profusion as when near plexi.

Within a short, 1–2 day, or considerably longer, 5–10 day period after the formation of these plexi, perithecia form in their outer regions (FIG. 2). Not all plexi bear perithecia, but most do so. In their early stages the perithecia are quite like those of *G. cingulata*, at first hyaline, later turning dark and showing reticulations. Though their development follows precisely as does that of *G. cingulata* they never attain a size greater than 110 m. Only immature ascospores were seen.

The young perithecia found on the edges of a plexus are borne on the hyaline mycelium. The perithecia first formed may be regarded as primary and are buried within the agar. The secondary crops of perithecia are superficial. It is quite possible that the primary perithecia are buried because the irradiation killed the superficial mycelium and that the secondary crop is superficial because it is borne on new growth since irradiation.

On one exceptional plate this fungus at one day after irradiation was decidedly and evenly darkened; four days after irradiation it showed numerous perithecia mostly hyaline, but some reticulated and slightly darkened and evenly distributed, not grouped in plexi over the whole of the irradiated area. At twenty days these perithecia did not exceed 55 μ in diameter and many were still smaller and hyaline. Sometimes the perithecia appear at a much later period even to twenty-three or thirty days associated with the usual special mycelial plexus.

It is quite typical of this species for the sexogenetic influence to extend over into nonirradiated regions; to new growth on the irradiated side or to old growth on the nonirradiated side of the

plate, and there superficial perithecia are formed. Such regions appear first after a considerable interval, even up to fifteen days, as areas of darkened mycelium. Ordinary new mycelial growth beyond the irradiated area is hyaline. Later perithecia develop in them or on them. Not all such dark regions produced perithecia, but all perithecial plexi that are formed in nonirradiated regions are in close proximity with plexi induced by irradiation.

The Georgian strain was tested by irradiation of thirty second repeated five times at intervals of two hours. There was no significant consistent difference in the number of perithecial plexi induced.

Variations in dosage gave the following:

1″ no perithecial plexi.
2″ no perithecial plexi.
15″ 7 perithecial plexi.
30″ 11 perithecial plexi.
60″ 6 perithecial plexi.
90″ 3 perithecial plexi.

In all instances plexi were more abundant in the zone that was one day old when irradiated.

From the study of over 1,000 acervuli of *C. lagenarium* one of my students (Mr. G. H. Boewe) whose results are as yet unpublished states, "data were obtained by studying some 1,000 acervuli and growing some 150 cultures. Of the total number of acervuli examined, there were forty-three more on the nonirradiated side of the colony that produced no setae than on the irradiated side.

"Of the number of acervuli that produced setae, there were more setae per acervulus on the irradiated side of the colony than on the nonirradiated side. There were 760 setae produced by 170 acervuli on the irradiated side as compared with 495 setae by 126 acervuli on the nonirradiated side of the colony. The portion of the colony which was irradiated produced the largest number of acervuli."

Usually, but not always, there are numerous pink acervuli scattered evenly over the nonirradiated growth while but few are on the irradiated area. Occasionally, however, the tips of

the mycelium when irradiated respond with numerous acervuli, thus forming a perfect arc marking the position of the mycelial tips when irradiated. Stronger dosage, however, may suppress them in the irradiated area (FIG. 3).

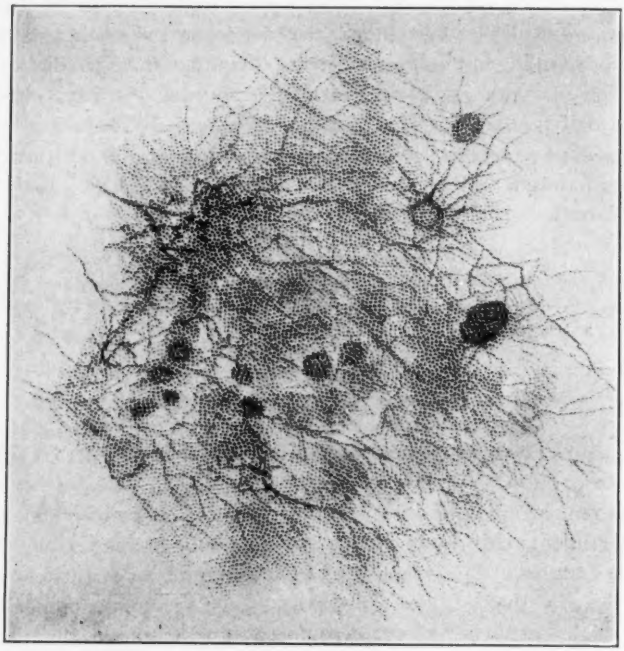

FIG. 2. Plexi of *C. lagenarium* showing perithecia.

Since the ascigerous stage of this fungus is not known and is clearly cogeneric with *Glomerella cingulata* I therefore propose its name as *Glomerella lagenarium* with the following synonymy.

Glomerella lagenarium (Pass.) Stevens, comb. nov.

Fusarium lagenarium Passerini, Erb. Critt. Ital. s. 2, No. 148. 1868

Gloeosporium lagenarium (Pass.) Sacc. & Roum. Rev. Myc. **2**: 200–202. 1880.

Gloeosporium reticulatum Roumeguère, Rev. Myc. **2**: 167–172. 1880.

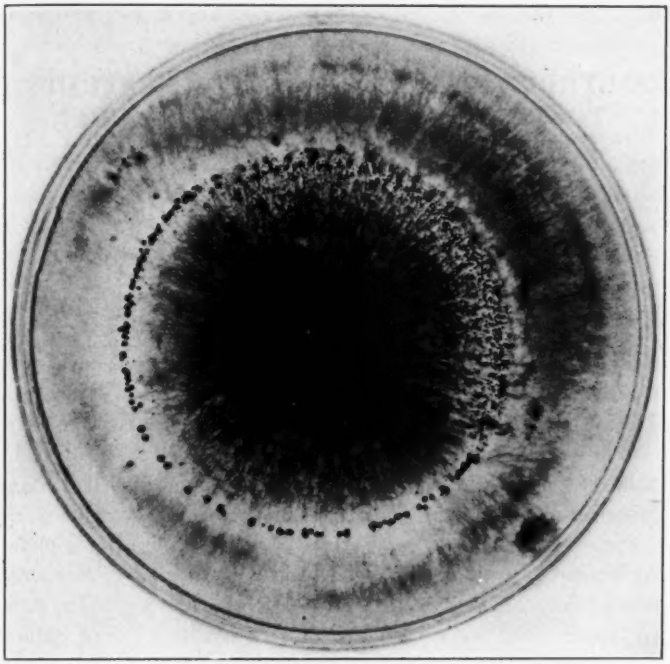

FIG. 3. *Colletotrichum lagenarium* showing a circle of acervuli in the non-irradiated area, none on the irradiated area.

Colletotrichum oligochaetum Cavara, Rev. Myc. **11**: 191. 1889.
Colletotrichum lagenarium (Pass.) Ellis & Hals. Bull. Torrey Cl. **20**: 250. 1893.

The species may be characterized as follows. Perithecia known only as induced on corn meal agar by ultra-violet irradiation, globose, dark, up to 110 μ in diameter; asci numerous. Spores hyaline, one celled. Conidial form *Colletotrichum lagenarium* (Pass.) Ellis & Hals.

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CONTRIBUTIONS TO THE CLASSIFICATION OF TORULOPSIDACEAE—I. AN AMERICAN VARIETY OF THE TORULOPSIS MINUTA

R. CIFERRI

(WITH[1] TEXT FIGURE)

INTRODUCTION

This strain (No. *151* of Ciferri collection) was isolated and partially studied by Starkey and Henrici (**7**), who discovered it together with yeasts and anascoporic yeasts in soils of Minnesota. The authors, who kindly sent it to the writer for further consideration of its systematic position, classified it under the provisional name of *Torula glutinis* with the following diagnosis: "The young cells are small and oval, and are relatively free from vacuoles and granules. In old culture the cells contain a large fat globule. Agar slant cultures are abundant and very mucoid in character. After a time most of the growth slides to the bottom of the tube. In liquid media some turbidity and an incomplete ring pellicle are produced. No fermentation occurs with any of the sugars."

Ciferri and Redaelli (**3**), who made a monographic revision of the anascoporic yeasts (Torulopsidaceae) pigmented in red, demonstrated that the *Cryptococcus glutinis* Fresenius, later on denominated *Torula glutinis*, is a specific entity still unknown. As a matter of fact the description is somewhat vague or incomplete; it lacks the essential cultural characteristics and nothing is said about its biochemical activities. In addition to this, there was doubt later on as to whether the *Bacillus prodigiosus* Flügge was included. Therefore *Cryptococcus glutinis* described by Engel under the name *Saccharomyces roseus* is probably different from *C. glutinis* Fresenius, and according to Vuillemin corresponds with *Saccharomyces Freseniusi*. Hansen admits the existence of two different *C. glutinis*, and Schröter confirms the view. As time goes by and further studies are made, a considerable number of strains are described under the name *C.*

glutinis, either taking as a basis the color of the colonies or the shape of the gemmate cells. To avoid a long list of authors, reference may be made to the monograph written by Ciferri and Redaelli (**3**),[1] who state that the species *Cryptococcus* (*Torula*) *glutinis* is insufficiently characterized, as it has not been decided yet whether it is a real Saccharomycete or a Torulopsidacea, and that several other species were grouped under the same name. We are therefore endeavoring to ascertain the exact systematic position of the strain of Starkey and Henrici.

CHARACTERISTICS OF CULTURES[2]

(In agar of Sabouraud, original formula, pH = 6.4, room temperature 22–32° C.)

Colony abundant, of rapid growth, thick, creamy, uniform, center somewhat thicker than edges, even or slightly irregular. Edges are plain, even or grossly sinuous, sometimes consisting of many small colonies, round or partially confluent. Its color[3]

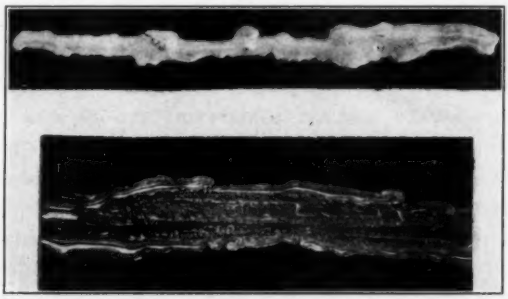

FIG. 1. Colony 3 days old, on must agar (1/2 nat. size). Colony 7 days old, on Sabouraud agar (1/2 nat. size).

changes from English red (7.R–0.i) to chestnut (9.0R–0.m) and to auburn (11.0.m) when the colony is old.

[1] Also for bibliographical references, refer to report by Ciferri and Redaelli (**3**).

[2] For methods of study of the Torulopsidaceae and the systematic position of these fungi, refer to Ciferri and Redaelli (**4**) and Redaelli and Ciferri (**5**).

[3] The nomenclature of colors is that of Ridgway, "Color Standards and Color Nomenclature." Washington, 1912.

In malt agar (Difco) (pH = 6.4). Colony similar to preceding but of lighter tints.

In agar of Gorodkowa (pH = 6.6). Culture not abundant. Colony of difficult growth, color changeable from shrimp pink (5.00–R.f) to safrano pink (7.R.0.f). Does not present special characteristics.

In must agar. Growth abundant and rapid. Colony similar to preceding, color changing to different shades of grenadine.

In glucosic broth agar (pH = 6.2). Culture entirely similar to that on agar of Sabouraud.

In corn meal agar (Difco) (pH = 7.2). Colony is almost white. Substrate entirely unfavorable; growth of colony slow and difficult.

In prune agar (Difco) (pH = 7.2). Colony of good development, very similar in type and color to that in malt agar.

In potatoes and carrot. Rapid and abundant growth similar in both substrata of culture. The type of colony is always the same; it lacks brilliancy on surface or this takes a porcelain varnish. Color changes from grenadine red (7.R–0) to English red (7.R–0.1) and later on to mahogany red (7.R–0.k).

In malt gelatin (Difco) (pH = 6.6). Colony somewhat rare, viscous and even creamy, at first quite thick and gradually partly liquated; edges indeterminate, central body partly depressed but without crater formation. Color changes from Brazil red (5.00–R.i) to ox-blood red (1.R.k).

Giant colony in must gelatin (pH = 5.8). Colony small, growth not very rapid, almost round, edges irregular, amply lobated, even and thin. The center is depressed and without special characteristics. Its growth is similar to that of the fundamental type I–II of Will. It may be considered as the typical colony of the Torulopsidaceae.

In pepto-glucosed water (pH = 6.4). With some difficulty a ring is produced (which however is incomplete and irregular) but no pellicle appears on surface. The deposit at the bottom of the tube is comparatively abundant, creamy-mucilaginous. The liquid remains clear, but gradually darkens without any peculiar odor. The color of the ring oscillates between orange pink

(11.0.f) and light salmon orange (11.0.d); the deposit oscillates between Sanford's brown (11.0.k) and raw umber (17.0–Y.m).

In must (pH = 5.2). Same as preceding but not so abundant and of lighter hues. The sediment is entirely mucilaginous.

MORPHOLOGICAL CHARACTERISTICS

In Gorodkowa substrata no ascospores are produced.

In cultures on solid media at laboratory temperature (22–32° C.) the cells are of various shapes, round, oval, elliptical, cylindrical or irregular. The protoplasm, originally hyaline and homogeneous, shows vacuoles in the old cells. The vacuole is generally single and central; only very seldom two vacuoles appear in polar position. The cellular membrane is thin and is only in evidence in old cells. Its dimensions are comparatively constant, varying from 3 to 5 μ in diameter or length. The giant cells are scarce or altogether absent; they are slightly larger than normal cells.

Cells on liquid cultures do not show marked morphological characteristics or changes. In the deposit at the bottom of the tube the cells are round or almost spherical, about 3 to 4 μ, occasionally 5 μ in diameter, and are never catenulate. The protoplasm is not very homogeneous and contains normally one or more crystalloids, with few or no vacuoles. In favorable liquid media, as malt water or grape must, minute chains of 2 to 3 cells are formed, sometimes of even 5 to 6 cells, which may then be smaller in size than on all the other substrata; from 2 to 4 μ.

The cells of the ring and velum do not differ widely from the preceding; the catenulations, while small, are almost constant; the cellular form is somewhat more elongate. The protoplasm normally contains one or two refractive corpuscles. The giant cells are rare, but present.

BIOCHEMICAL CHARACTERISTICS

Does not ferment maltose, dextrose, galactose, saccharose, trehalose, lactose, mannose, arabinose, xylose, dulcite, inulin, mannite, dextrine and starch. Assimilates fairly glucose, levulose and saccharose; does not do well in lactose, galactose, inulin and mannose in which it acidifies the liquid.

Assimilates indistinctly tartaric or citric acid; not so well malic and acetic acids; does not assimilate well methyl and ethyl alcohol, but it does well in glycerine.

Assimilates preferably peptone and asparagine quite well; not so well ammonium sulphate and potassium nitrate, but does not assimilate at all potassium nitrite. Liquefies slowly gelatin; generates sparingly hydrogen sulphate from sulphur; reduces actively the methylene blue. Acidifies neutral media and stands one pH = 3.0 in water of autolytized yeasts, although its multiplication is then very limited. Coagulates milk slowly in which medium it lives well. Does not form tryptophan and indole in pepto-glucosic broth, and does not give the biuret reaction. Does not decompose the trehalose and in the case of the raffinose, if any, the decomposition takes place slowly and with difficulty, but it inverts saccharose generously.

SYSTEMATIC POSITION OF THE YEAST

This strain should be classified under the genus *Torulopsis* Berlese emend. Ciferri nec Oudemans. Asporigenous species of yeasts with red pigments, studied wholly with regard to their cultural, morphological and biochemical characteristics, have been found to present similar characteristics with *Torulopsis Montii* Ciferri and Redaelli, distinguished by the great instability of its color and by its low vitality, the thick and numerous giant cells, without marked polymorphism and polymetrism and by its assimilative powers. It differs from the *Torulopsis Saitoi* Ciferri and Redaelli by the cells being sometimes larger, by the type and growth of the giant colony, the type of velum produced in liquid media and also by its assimilation, chiefly of nitrogenous substances. It differs from *Torulopsis saccharophoba* Ciferri and Redaelli, and *T. Biourgei* Ciferri and Redaelli, by the absence of cells which are biscuit shaped and ellongate, by the giant cells appearing very distinct. It differs from both species by its biochemical characteristics, more especially so from *T. saccharophoba* than from the other *Torulopsis*. The biochemical properties also distinguish the strain in question from *Torulopsis corallina* (Saito) Ciferri and Redaelli (= *Torula corallina* Saito), whose assimilative powers are different and which does not acidify

the liquid culture media. However, this species is quite similar to our strain, as is also *Torulopsis rufula* (Saito) Ciferri and Redaelli (= *Torula rufa* Saito), whose giant colonies differ in shape and color and whose assimilative powers are different. The species which may be regarded closer is *Torulopsis minuta* (Saito) Ciferri and Redaelli, isolated from dust of the air in Manchuria. This species was originally studied by Saito (**6**), who classified it under the name *Torula minuta*, and was later further investigated, especially with reference to its biochemical activities, by Ciferri and Redaelli (**3**), who, according to nomenclature adopted by them, classified this species in the genus *Torulopsis*. Its morphological characteristics are the same; the protoplasm of *T. minuta* contains fat corpuscles. As regards the characteristics of cultures, there appears to be no noticeable difference, only slight nuances in color, and in liquid media it forms only the ring. In the biochemical characteristics a few differences are noticed. The affinities between *T. minuta* and our strain are the following: both lack fermentative power; they liquefy gelatin slowly; have no action on starch, cause limited generation of hydrogen sulphate from sulphur; do not form indole in peptoned water; do not assimilate potassium nitrate and only to a slight extent ammonium sulphate; little or no assimilation of ethyl and methyl alcohol; poor assimilation of saccharose.

The differences consist in that the strain in question causes a slight acidity on certain liquid substrata, assimilates well peptone, and fairly well asparagine, inverts saccharose but without acting on the trehalose; assimilates quite well glucose, levulose and saccharose.

The strain under review should be included in the cycle of *Torulopsis minuta*, but owing to its different biochemical activities may be classed in a variety we shall call *americana*.

This is the diagnosis:

Torulopsis minuta (Saito) Cif. & Red. var. **americana** Cif. var. nov.
= *Cryptococcus glutinis* Starkey & Henrici.

Differs from the type by the presence of giant cells and of small chain-like cells, by the assimilation of peptone and asparagine,

inversion of saccharose but not of trehalose and assimilation of glucose, levulose and saccharose.

Habitat: the soil, in Minnesota, leg. Starkey & Henrici.

It should be noted that the *Torulopsis minuta*, which does not appear to have been found again after its discovery by Saito, is really a cosmopolitan or widespread species, while, owing to its adaptation to new environments, it has changed some of its characteristics. We might mention that, in addition to this North American variety, we have found another variety (var. *parvissima* Cif. & Ashf.) in Porto Rico.

NAT. AGR. STA. AND COLL. OF AGR.,
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THE CONCEPT OF MYCORHIZA

ARTHUR PIERSON KELLEY

Fungus-roots, structures which have attracted so much attention in recent years, were probably known to Greeks of the 4th century B.C., since Theophrastus [1] speaks of fungi which grow upon or beside roots of oak as well as of other trees. These fungi, of course, may have been saprophytes or parasites but there is considerable probability that they were mycorhizal fungi.

A short paper, sometimes stated to have been the first on fungus-roots, was written by Meyen in 1829. It was concerned with the species of *Rafflesia* and *Orobanche*, which he properly considered to be parasites upon other plants. He noted also the short bunches of rootlets formed terminally or laterally on the roots of *Alnus glutinosa*, and called these structures parasites also, considering them to be species similar to *Orobanche* but less highly developed. We now know that the clustered structures are part of the alder roots and that they are primarily infested by bacteria. Other structures described by Meyen from beech roots were possibly true fungus-roots in a strict sense. They underwent, he said, a specific metamorphosis to form short thick branches with pad-like tips, but he considered them to be developmental stages of the parasite *Lathraea*.

The question of the first paper on the subject is of historical interest only, since the first one to draw wide-spread attention to fungus-roots was that of A. B. Frank (1885), in which he told of the occurrence of fungi on the roots of forest trees in Prussia. To the morphological formation of fungus and root which had earlier been called a "fungus-root," Frank gave the name "Mycorhiza": "Der ganze Körper ist also weder Baumwurzel noch Pilz allein, sondern ähnlich wie der Thallus der Flechten, eine Vereinigung zweier verschiedener Wesen zu einem einheitlichen morphologischen Organ, welches vielleicht passend also

[1] *οἱ γὰρ μυκητες ἀπὸ τῶν ῥιξῶν καί παρὰ τὰς ῥιξας φυόμενοι κοίνοι καί ἑτεριον εἰσιν.*—Enquiry into plants, 3.7.6.

Pilzwurzel, Mycorhiza, bezeichnet werden kann" (l.c., p. 129).

Mycorhiza, then, is a word spelled originally with one letter r. The word is derived from the Greek words μύκης (fungus) and ῥίξα (root), and is Latinized in form. Being adopted into the German language, we soon find (at least as early as 1892) a doubling of the letter r to form "Mycorrhiza." This is the usual practice when a prefix is added to a Greek root commencing with r, and has been adopted almost universally by British botanists, and by individual botanists in other countries. In the Germanic languages it was natural to change the letter c to k and thus we find the spellings "Mykorhiza" and "Mykorrhiza" with plurals "Mykorhizen" and "Mykorrhizen." Scandinavians generally use the same spellings. In French the word becomes "mycorhize" (pl. "mycorhizes"), seldom with a doubled r. In Italian the word is "micorize" (pl. "micorizen"). Most American work has been published with the word spelled "mycorhiza" and the plural usually "mycorhizas," although it is sometimes written "mycorhizae." The spelling "mycorhiza" has historical preference [2] while the phonetics of "mycorhizae" are certainly more pleasing than those of "mycorhizas."

Usage of the plural, however, is not uniform, for frequently the singular form of the word is used when obviously it is intended to express plurality.

As originally used the word meant (1) the morphological union of fungus and root (*vide supra*). This is apparently a mutualistic union. Where the fungus is parasitic, the fungus and the parasitized structure form a "pseudo-mycorhiza," using a term suggested by Melin.

After Frank's publication it was found that exactly similar conditions occur in non-vascular plants, and that fungi live in tissues of mosses and liverworts (see, *e.g.*, Beauverie, 1902). These unions of fungus with tissues not of roots were now called mycorhizae also, and we may speak, for example, of the mycorhiza of a liverwort. The relationship is essentially that of fungus-

[2] Lek (1929) also concluded: "Tegenwoordig wordt, vooral door Engelsche auteurs, het woord veelal "mycorrhiza" gespeld. Daar het feitelijk "mycarhiza" of "mykorrhiza" zou mieten zign, zign taalkundig beide spellingen onjuist. Ik hand mij daarom maaraan het woord, zooals Frank (1885) dit invoede" (l.c., p. 146).

hyphae to individual cells or of a hypha to a cell, and to carry the definition (**2**) to its logical conclusion we should call the symbiosis (de Baryan definition) of fungus with an alga cell a mycorhiza. No satisfactory term has been proposed for the relationship and the use of the term "mycorhiza" is already well established.

Frequently, especially in popular usage, the fungus associate is spoken of as a mycorhiza, and it is even said that a mycorhiza ramifies through the soil, finally penetrating into the root. This definition (**3**) finds authority in Sir James Murray's dictionary (1908): "*Myco* (mei-ko), irreg. combining form (for Myceto-) of Gr. *μύκης*, fungus, used in chemical and botanical terms: . . . *Mycorrhiza* (Gr. *ῥίξα*, root), a fungus investing the roots of certain trees and living in close relationship with the surface cells; hence *mycorrhi-zal* a. 1898 tr. *Strasburger's Bot.* 210. Judging from the results of culture experiments made with these plants without mycorrhiza. 1900 Nature 28 June 201/2. All known species of mycorrhizal fungi."

It is too obvious to require pointing out that this definition includes only part of the phenomena involved. Nevertheless, the use of definition (**3**) is common, as when Peyronel (**1922**) speaks of the "normalle presenza di micorize nel grane e in altre piante coltivee e spontanee"; or Dandeno (**1910**) states that "mycorhiza shows a step further in adaptation, inasmuch as they attach themselves to the roots . . ." (l.c., p. 35).

The opposite possibility (**4**), of a root without fungus being called a mycorhiza, finds tangible support in the practice of calling an old mycorhiza by the term after all or practically all of the hyphal material has disappeared from the cells. The cells of such tissues are called, after Magnus, "Verdauungszellen."

Not only true fungi are said to cause mycorhizae, but bacteria as well (**5**). Thus the nodules found on alder, *Elaeagnus* and other plants, earlier thought to be caused by "Schinzia" but now shown to be due primarily to Rhizobia (or "Rhizobacteria"; Dangeard and Truka, 1929), have been called mycorhizae (cf. Hiltner, 1903).

The word is used further, not to express the existence of a concrete entity, but (**6**) an abstract idea, the "association" of

fungus and root. This is the definition of Webster's Dictionary (Merriam ed., 1927): "The symbiotic association of a fungus with the roots of a seed plant, as those of the beech and other Fagaceae, those of many heaths (Ericaceae), orchids (Orchidaceae), and most saprophytes." From the literature we might cite Paulson (**1924**): "The close association of a fungus with the rootlet of a higher plant produces the phenomenon known as mycorrhiza or fungus root, . . ." (l.c., p. 213).

The varied usages of the term are illustrated in the account of "mycorrhiza" found in the Encyclopedia Britannica, fourteenth edition (1929): ". . . *mycorrhiza*, that curious and interesting partnership between the roots of vascular plants and fungus mycelium now known to affect a vast number of the higher plants and to be of great importance in their lives."

Mycorrhizae or fungus-roots (*μύκης*, a mushroom) (*ῥίξα*, a root) are formed alike by wild and cultivated plants, . . . in 1885, the German botanist, Frank, coined the new name, 'mycorrhiza' (*sic*), ..." In this brief account we have the word "mycorhiza" made to mean first (abstract) an association and second (concrete) a structure (fungus-root).

We may summarize the meanings given to the word "mycorhiza":

Concrete: Fungus and root (mutualistic symbiosis)
Fungus and plant tissue, organ, or body
Fungus
Root
Bacterial nodule

Abstract: "Association" of fungus and root (By inference, "association" of fungus (or bacteria) with plant tissue, organ or body)

Language is naturally subject to development and as continually more ideas are attached to a particular term it becomes necessary to state precisely the exact significance given to the term as it is used. In a strict etymological sense, the word "mycorhiza" means a structure, a fungus-root, and to such a structure the term is most logically applied. In the literature the term is losing its significance and we may find ourselves

under the necessity of inventing new words, each with a more nearly precise meaning.

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VOLVARIA SPECIOSA

JOHN DEARNESS

Mycophagical authorities are widely divided in their opinion of the edibility of *Volvaria speciosa* Fries; therefore it seems worth while to publish this report of an actual experience.

On Nov. 25, 1927, Mr. E. Davis of Davis Bros., market gardeners, Byron, Ont., brought me a number of fine specimens of a mushroom, which proved to be *Volvaria speciosa*, that he said had appeared spontaneously in the beds in two of their lettuce houses. He was naturally interested in the edibility of the species; so I showed him its published reputation ranging from that of McClatchie, quoted by Lloyd and McIlvaine—"a fine edible agaric and our most abundant one in California"—to that of W. D. Hay and others who label it "poisonous."

A month later, to be exact, on Dec. 27, Mr. Davis brought me a basket of the *Volvaria* for trial as an esculent and told me the story of his experience. He said that they continued to shoot up in abundance in two of the houses—he had counted as many as 66 fine mature plants at one time—and that they looked so clean and attractive that he risked cautiously testing McClatchie's verdict. Finding no ill effects from the trials, he and his family and their friends had been eating them for a couple of weeks or longer.

I used the opportunity of sampling the contents of the basket. The plants could not be in finer condition for the pot. They proved to be edible without a doubt but to my taste their quality was not high. On the basis of 100 for the meadow mushroom at its best these seem to rate about 60. Portions kept over developed a strongly disagreeable odor; possibly the bad reputation of the species is due to eating old plants.

This is a composite description of the finest half-dozen that came into my hands:

Volvaria speciosa Fries. Cap white, pale watery yellow at the center, subglobose-bell-shaped at first becoming widely

campanulate and obtusely umbonate, covered with a thin gluey viscidity, drying striate on the margin. Cuticle thin, separable half way to the umbo. Flesh thin, open-grained; odor hardly perceptible to unpleasant; taste rather insipid. The largest campanulate cap 15.8 cm. over the top and covering a circle 12.5 cm. in diameter (4 to 6½ inches); weight 2½ to 3½ ounces.

Gills flesh color to rusty; free from the stem.

Stem reaching 18 cm. in length, slender for its height, not hollow, white, slightly tapering upwards, sheathed for an inch or two at its base by a white, tomentose volva.

Spores rusty-flesh color, large, 16–17 by 7–9 microns, but varying a good deal beyond these limits.

Fruiting abundantly in richly manured sandy loam.

Contradiction of opinion regarding the edibility of this *Volvaria* may be due to confusion of names. Most authors regard *V. gloiocephala* DC. as poisonous. P. Dumee (1909) declares that the last name belongs to *V. speciosa* Fries and accordingly transposes the two names. Rea in British Basidiomycetes (1922) lists *V. gloiocephala* (DC.) Fries as poisonous and cites Maire as reputing *V. speciosa* Fries to be edible. Maublanc (1926) makes *V. speciosa* Fries a synonym of the other name and states that the investigations of Chauvin and Gauthier have proven it—or both—to be edible.

LONDON, ONT.

THE OCCURRENCE OF SCHIZOPHYLLUM COMMUNE ON GREEN APPLES

F. D. Bailey & S. M. Zeller

(With 1 Text Figure)

We have just read with interest the report of the infection of dormant sweet potatoes by *Schizophyllum commune*.[1] This is an interesting additional type of host for this fungus. In this connection the authors thought the occurrence of this fungus on green apples worth a note. In the fall of 1926 in an orchard in

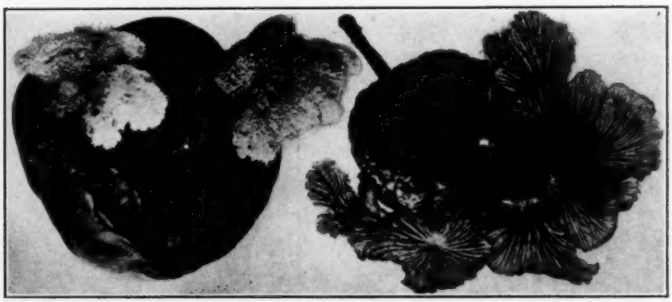

Fig. 1. Apples with sporophores of *Schizophyllum commune*.

Marion County, Oregon, the green apples thinned from the trees during the summer literally covered the ground under the trees. As a rule the upper surface of many of these apples was sunburned and shriveled but otherwise they were well preserved. In a high percentage of cases, however, these apples under Spitzenberg and Red Cheek Pippin trees were infected with *Schizophyllum commune*. The affected tissue was a brown dry rot. Any cavities in the tissues were filled with fungous felt and in many cases the apples were covered with this white felt. By October

[1] Poole, R. F. Sweet potatoes infected by *Schizophyllum commune*. Jour. Elisha Mitchell Sci. Soc. **45**: 137–139. *illus*. 1929. (Rev. Appl. Myc. **9**: 267. 1930.)

and November these apples had taken on wings in the form of mature sporophores. These originate at most any point on the surface of the apple or stem. Two of our many illustrations are presented herewith (FIG. 1).

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NOTES AND BRIEF ARTICLES

Doctors B. O. Dodge and Fred J. Seaver attended the Annual Meeting of the American Association for the Advancement of Science as representatives of The New York Botanical Garden in mycology and pathology.

Dr. L. O. Overholts of the Pennsylvania State College instead of attending the meeting of the American Association for the Advancement of Science at Cleveland spent several days at the Garden studying over collections of Polyporaceae. He was missed at the meeting where he has been very regular in his attendance during past years.

The Cleveland Meeting

The meetings of the Mycological Section of the Botanical Society of America were held at Cleveland this winter in connection with the American Association for the Advancement of Science as usual. The first meeting of the mycologists was held on Tuesday morning at ten o'clock in the geological building of Western Reserve University. The attendance was about sixty and rather larger than usual. Ten papers were scheduled for the first meeting but three of these were not presented owing to the absence of those scheduled to take part, so that the first meeting closed more promptly than usual.

Wednesday morning a joint session of the Mycological Section and the American Phytopathological Society was held. This was a de Bary program and throughout most interesting. Dr. W. H. Weston of Harvard University gave a very vivid account of the early life and work of de Bary laying special emphasis on the fact that it was de Bary's personality as much as his work which impressed itself upon the hearts of his students. Dr. L. R. Jones of the University of Wisconsin gave a discussion on "The Concept of Parasitism, a Development of de Bary's Early Works." Following this Dr. J. C. Arthur of Purdue University

discussed the problem of heteroecism emphasizing the fact that heteroecism was not first discovered by de Bary although he was one of the first to use the culture method in working out the life histories of the rusts. It was this phase of de Bary's work which impelled Dr. Arthur to take up this line of investigation in which he has contributed much to our knowledge of the rusts. Dr. D. Reddick of Cornell University spoke on "Die Kartoffelkrankheit" and Dr. G. W. Martin of the University of Iowa on de Bary's work so far as it affected "Die Myzetozoen."

The last meeting of the Mycological Section was held on Thursday morning, January 1, the attendance being slightly smaller than that of the first meeting owing to the fact that some had already left for their homes. A number of interesting papers were presented and lively discussion ensued.

In addition to the regular mycological programs, Dr. B. O. Dodge of The New York Botanical Garden, by a special invitation presented his work on "Hybridization and Inheritance in Ascomycetes." The paper as presented was received with much interest on the part of those who heard it. The results of this work were published in the January–February issue of MYCOLOGIA.

VIRGINIA